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AUGUST-SEPTEMBER 1950

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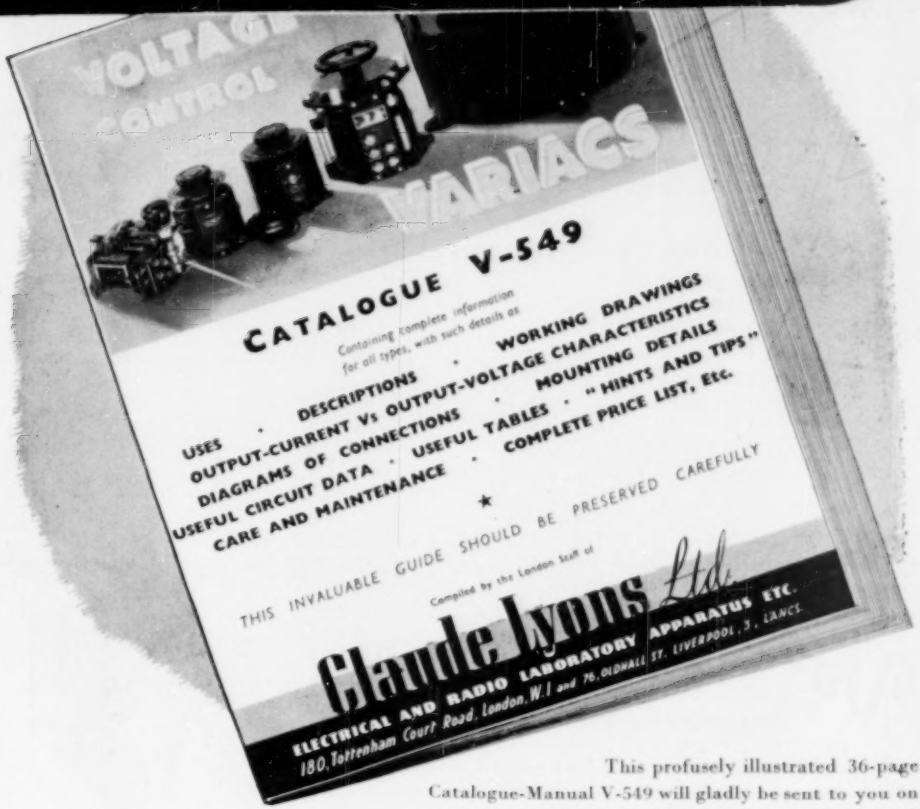
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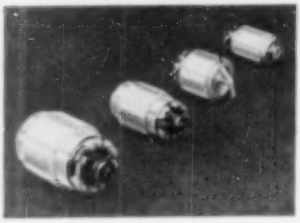

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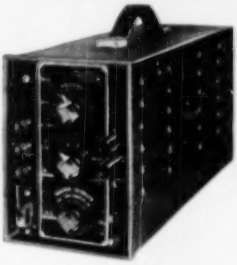

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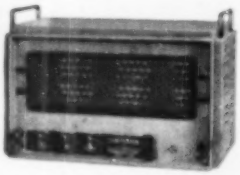

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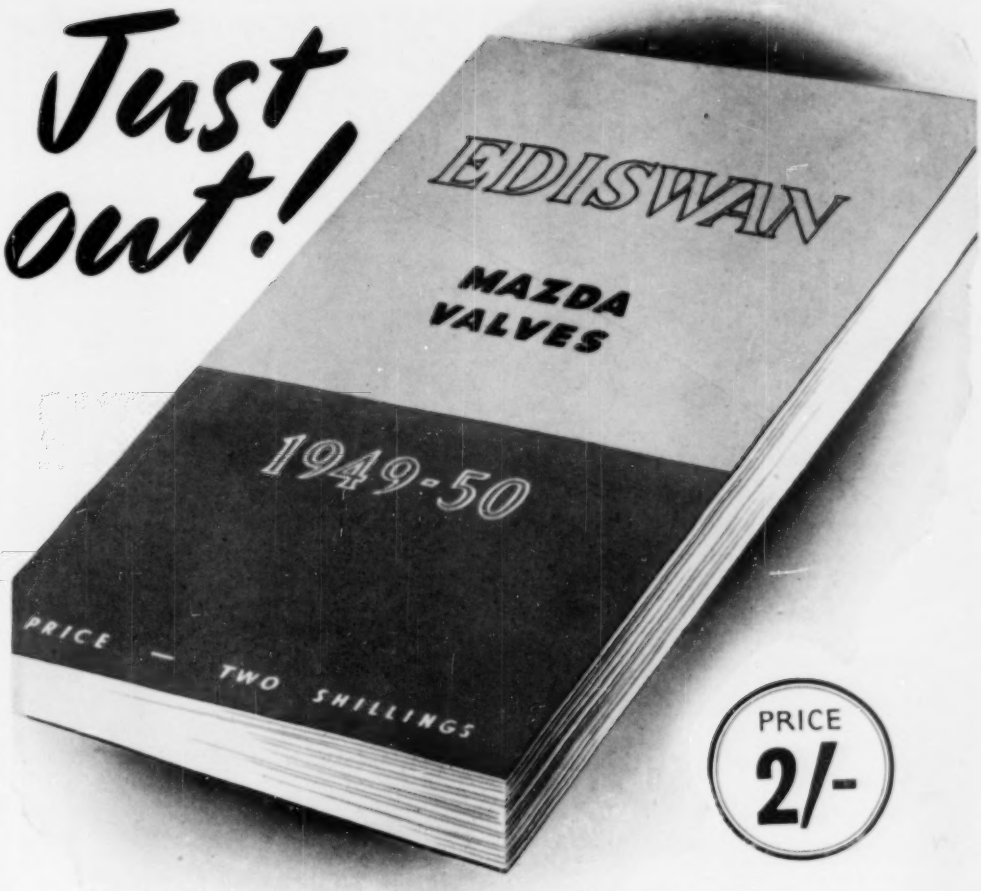

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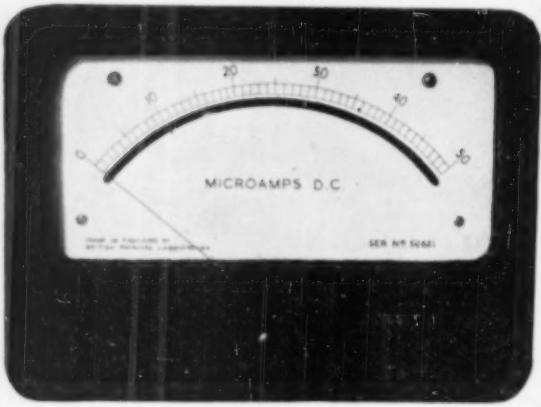

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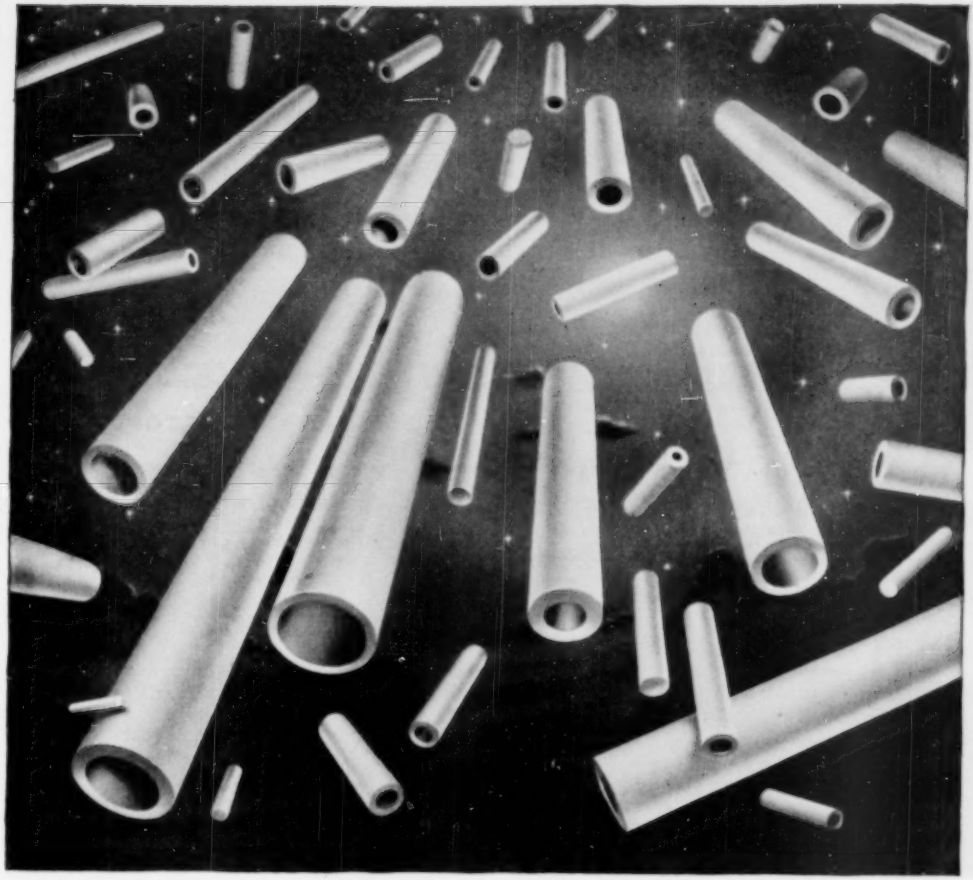

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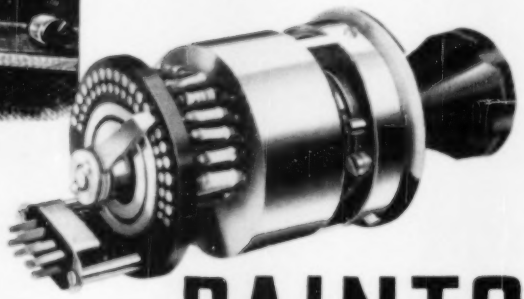

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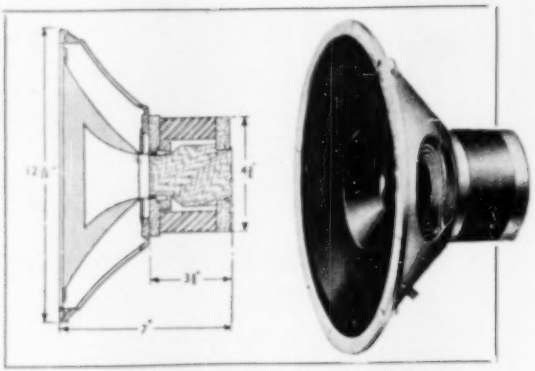

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We have had an opportunity of hearing the Axiom 22 with an Axiom 12 as reference standard, and there can be no doubt of the improvement conferred by the increased flux density. Sensitivity is of course higher but the outstanding impression is one of tautness and the grip the Axiom 22 has on transients. The increased magnetic damping is no doubt also responsible for an apparent reduction in intermodulation from self-generated transients, and a consequent improvement in 'presence,' and the segregation of the instruments of the orchestra.

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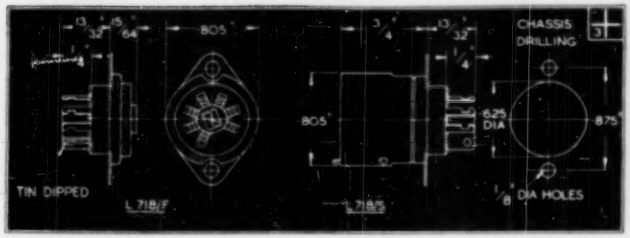

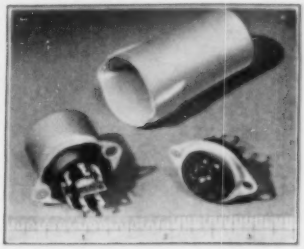

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L718/F with Flange
L718/S with Skirt

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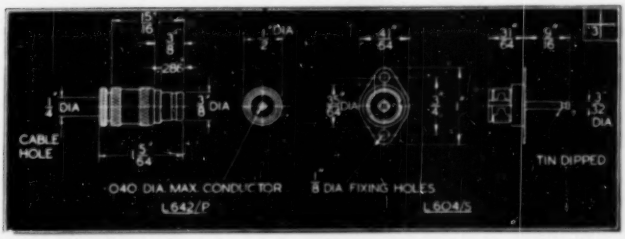

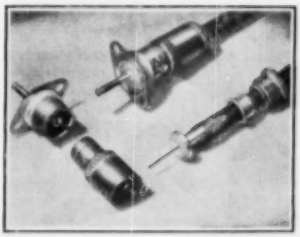

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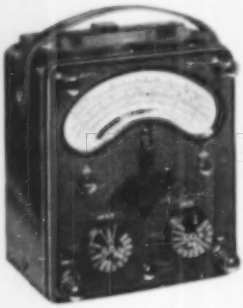

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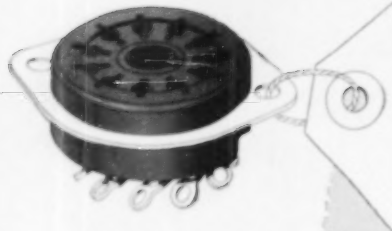

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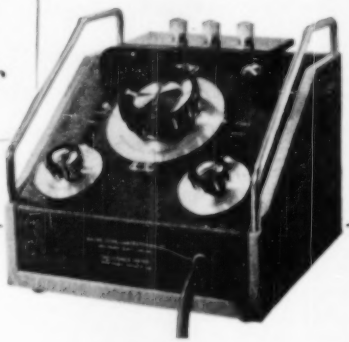

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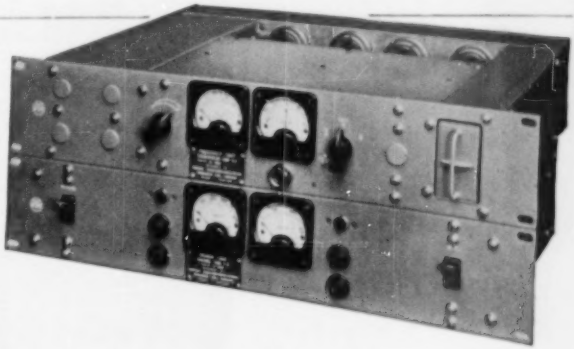

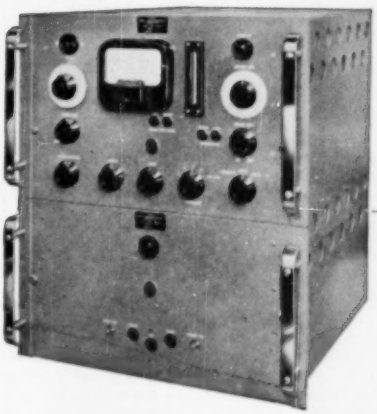

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AUGUST-SEPTEMBER 1950

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Mullard

REVIEW OF NEW AND CURRENT VALVES

MULLARD DISC-SEAL TRIODES FOR U.H.F.

For U.H.F. links, local oscillators and wide band applications such as multi-channel communication systems, radar altimeters, etc., the use of frequencies up to 1,500 Mc/s or even 3,000 Mc/s is often required. The Mullard Disc-Seal Triodes have been designed specifically for such purposes. In the ME1001, adequate cooling and low inductance are combined in the design of the anode and grid discs to give an anode dissipation of 10 watts and an upper frequency limit (as an oscillator) of 3,750-3,500 Mc/s (8-8.5 cm).

The ME1003 is basically similar in design to the ME1001 but the larger electrodes permit an anode dissipation of 25 watts. However, the larger clearances necessary to obtain this value, limit the upper frequency to 2,500 Mc/s.

PRINCIPAL CHARACTERISTICS

	ME1001	ME1003
Heater Voltage (V)	6.3	6.3
Heater Current (A)	0.4	1.0
Max. Anode Voltage (V)	350	400
Max. Anode Dissipation (W)	10	25
Max. Anode Current (mA)	50	200
Max. Peak Anode Current (mA)	150	600
Power Output (W)	0.5 (at 3,000 Mc/s)	5 (at 1,500 Mc/s)
	3.5 (at 500 Mc/s)	15 (at 430 Mc/s)
Mutual Conductance (mA/V)	6	12
Amplification Factor	30	30

A NEW PHOTOMETRIC CELL

The Mullard Photometric Cell Type 57CV has a specially prepared cathode of caesium-on-oxidised-silver, and is intended for use in circuits designed for making accurate photometric measurements in the red and infra-red region of the spectrum. The sensitivity of the cell, measured with a lamp of colour temperature 2,700°K at 0.1 lumen, and with the total area of one side of the cathode illuminated, is 25 microamperes per lumen. Other characteristics are:—

Dark current at 100V
10^{-8} μA max.

Anode Supply Voltage
100V

Cathode Current (each side)
5μA

MULLARD ELECTROMETER VALVES

The Mullard group of Electrometer Valves listed below is finding an increasing number of industrial, research and medical applications which involve the measurement of direct currents of up to the order of 10^{-16} amperes. The ME1400 is particularly suitable for users of photocells who wish to take advantage of a high grid resistance.

Type	Description	V_a (V)	g_m (μA/V)	μ	I_{g1} (A)
ME1400	A 4.5V Electrometer Pentode on an octal base suitable for use in high resistance circuits, e.g. pH meters, photocell units, and valve voltmeters.	45	240	—	10^{-11}
ME1401	A 1.25V sub-miniature Electrometer Triode especially suitable for use in nuclear radiation dosemeters.	9	80	1.7	12.5 $\times 10^{-14}$
ME1402	A 1.25V Sub-miniature Electrometer Tetrode especially suitable for use in nuclear radiation dosemeters.	4.5	10	1 (μ_{g_2})	$(I_{g_1} + I_{g_2})$ 5×10^{-14}

INDUSTRIAL POWER VALVES
THYRATRONS · INDUSTRIAL RECTIFIERS · PHOTOCELLS · FLASH TUBES · ACCELEROMETERS CATHODE RAY TUBES · STABILISERS AND REFERENCE LEVEL TUBES · COLD CATHODE TUBES ELECTROMETERS, ETC.

If you require full technical data on any of the valves described in this review, please check this form, pin to your letter heading and post to the address below.

DISC-SEAL TRIODES - - - ☐
PHOTOMETRIC CELL - - - ☐
ELECTROMETER VALVES - - ☐

MULLARD ELECTRONIC PRODUCTS LTD., CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2

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WIRELESS ENGINEER

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Simplifying Assumptions

IT is a common practice to assume that certain elements of a circuit have a negligible effect on its performance and to ignore them in analysing the circuit and explaining its action. It is often essential to do this if the analysis or explanation is not to become prohibitively complex.

We are, however, a little worried about the light-hearted way in which some authors make simplifying assumptions. All too often they take it for granted that their readers will know by instinct what simplifying assumptions have been made and the conditions under which the resulting error is negligibly small. We fear that sometimes this occurs because the author himself does not know—he has perhaps made use of some well-known equivalent circuit to simplify his problem without stopping to ask himself if the circuit does, in fact, adequately represent matters in his particular case.

More often, however, it arises because the author assumes too much knowledge on the part of his readers. There is a common tendency for authors to forget that readers know less about their subject than they do themselves.

It is not suggested, of course, that it is necessary for an author to mention in detail every simplifying assumption which he makes. Some are so common and so elementary that, except when writing for the beginner, an author can assume his readers to be familiar with them. When they are less common, however, or are widely used only in a particular branch of radio, he must certainly draw attention to them, and he must always deal with them very fully when his simplifying assumptions introduce more than a negligible error.

We have been led to these remarks by a case which recently came to our notice in which a simplifying assumption affects results to quite a small extent in one respect but to a very large extent in another. As far as the wanted output is concerned the real and the ideal circuits behave nearly alike but the waveforms in a branch of the circuit are quite different.

In setting up and adjusting the circuit it is actually very convenient to observe the waveform in this branch and the discrepancy can, therefore, be very misleading. It was through doing this that we came to observe it.

The effect occurs in a circuit which is in common use in the line-scanning circuits of present-day television receivers and it forms a good example of the need for authors to explain their assumptions. It is also interesting in its own right and as we have never seen it previously described we propose to treat it in some detail.

In an electromagnetic-deflection circuit the inductance, stray capacitance and resistance form a damped oscillatory circuit. During fly-back the valves associated with it are cut off and the circuit is allowed to execute very slightly more than one-half cycle of damped oscillation, so that the current changes from an initial value of, say, i_0 in the deflector coil to a new value, say, $-i_1$ at the end of fly-back. The magnitude of i_1 is always less than that of i_0, but in low-loss circuits it can approach it.

The withdrawal of overtime working by a section of the printing industry made it impossible to produce the August issue of *Wireless Engineer*. In order to maintain continuity, this issue is dated August-September. A slight reduction in the number of pages and some delay in publication are still unavoidable. All journals printed in London are similarly affected, to a greater or lesser extent, but journals printed in the provinces are unaffected.

The voltage across the circuit rises to a maximum when the current is changing most rapidly and takes a value v_1, say, when the current is $-i_1$. The voltage is then of opposite polarity to that prevailing through the major part of the fly-back period.

If such a circuit is left to itself it will go on oscillating until all the energy initially stored in it has been dissipated. To prevent this a biased diode is connected across it as in Fig. 1.

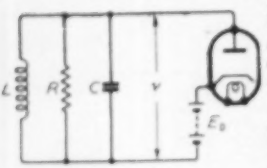

Fig. 1.

At the end of fly-back when the voltage v rises to v_1 and equals E_b, it is of the same polarity as E_b and the diode becomes conductive. Ideally it then acts as a switch to connect E_b across the LCR circuit. Since v is then maintained constant by E_b the subsequent decay of current in L is linear and can form the initial part of the next scanning cycle. This reduces the peak current which the driving valve (not shown in Fig. 1) need provide. In addition, E_b can be replaced by an auto-bias circuit and the energy passed to it by the linear decay of current in L can be employed usefully in the second part of the scanning cycle.

It is clear that the diode current should have the waveform sketched in Fig. 2 (a). It is not, of course, exactly like this because the series resistance of L and the internal resistance of the diode have been neglected. These round off

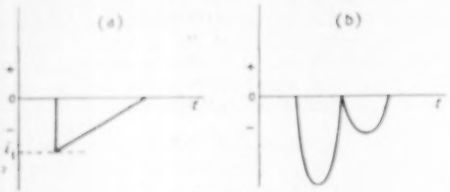

Fig. 2.

the initial rise of current and make the decay exponential but the effects can be mitigated very largely by making E_b a time-variable, instead of a fixed, voltage. The current waveform through the diode should thus be quite close to that of Fig. 1 (a). Instead, it is observed in practice to have the form sketched in (b). This is so very different that it is disconcerting to find it.

In practice, of course, a transformer is nearly always used to couple the driving valve to the deflector coil. It is invariably assumed in published explanations of the circuit that this does not affect matters. This is not true, however, for there is inevitably a leakage field in a transformer and the current produced by the release of the energy stored in this leakage field cannot be controlled by a diode connected to one winding. This is obvious when one thinks about it because the leakage field is merely that part of the field produced by one winding which does not link with the other.

The reason for the waveform of Fig. 2(b) is easily seen by considering the 'equivalent' circuit of Fig. 3. Here L_s represents the secondary inductance of the transformer and L_l the leakage inductance referred to the secondary while L_L is the inductance of the deflector coil and C_p' and C_s are the primary and secondary circuit capacitances, C_p' being the effective value for a unity-ratio transformer. This will be recognized as a well-known equivalent circuit of a transformer.

When the diode conducts the currents have

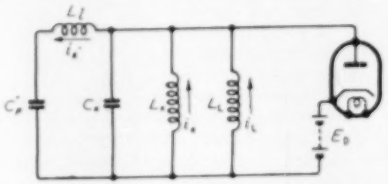

Fig. 3.

the directions shown and initially $i_s' = i_s + i_L$ so that the initial diode current is zero. If the diode holds the voltage across L_L constant at E_b, the current $i_s + i_L$ decays linearly and produces the triangular waveform of diode current of Fig. 1(a). The current i_s', however, flows initially in opposition through the diode and it flows in the oscillatory circuit $L_l C_p'$ which is completed through the diode. The current decays in oscillatory fashion and the total diode current is its sum with the triangular current. The peaks and troughs of the total current are produced by the periodic reversal of the oscillatory current. If this is lightly damped it may exceed the triangular current after a few cycles and, as the diode cannot pass a reverse current there will then be gaps between successive 'half sine waves' of total current. If the diode is connected to the transformer primary a similar effect occurs involving L_l and C_s.

If the diode has zero resistance when conductive the decay of current in L_L is unaffected because $C_l L_p'$ is a separate circuit. Thus the simple explanation is adequate so far as conditions in the deflector coil are concerned but very misleading about the diode current. In practice, the diode has resistance which acts to couple

the two circuits together. The oscillatory current in L_1C_g' does then modify the decay of current in L_2. It produces an oscillatory component in it which is sometimes large enough to produce a visibly distorted scan.

The effect is, therefore, not always negligible even for the useful scan so that it is hardly justifiable completely to ignore it even when only this is considered. It is definitely misleading to ignore it in a general treatment because one of the first and most obvious things to do when checking such a circuit is to check the diode-current waveform.

It may be noted in passing that while the diode circuit can be used to recover energy from L_2 and L_3 it cannot do so from L_1. The energy stored in the leakage field of the transformer cannot be recovered in this way and it can amount to as much as 30% of the total energy in the circuit.

All this affords a good example of the need for care in making simplifying assumptions. It is very tempting to ignore the leakage inductance of a transformer but it is unwise to do so.

W. T. C.

TUNED ABSORPTION CIRCUITS

Analysis and Characteristics

By R. E. Spencer

(E.M.I. Engineering Development, Ltd. Hayes, Middlesex)

SUMMARY.—This paper is concerned with the arrangement of coupled circuits in which input and output terminals are connected to the same tuned circuit and a coupled circuit absorbs power over a comparatively narrow band of frequencies.

It shows, with approximate formulæ, the various response curves obtained when the secondary is tuned to give a minimum response to a signal at a frequency f_{min}, and the primary to give a maximum response to a signal at f_{max}. It describes how the shape is affected by the difference between these two frequencies, and shows that if this quantity is less than a certain value (5 per cent of the mean frequency in a practical case) the greater peak will not occur at a frequency anywhere near f_{max}.

The depth and shape of the trough are also discussed.

Introduction

MUCH has already been written on the subject of the conventional band-pass circuit, in which a signal is fed to a resonant circuit, and an output is taken from a second resonant circuit which is coupled fairly weakly to the first. The subject has been analysed quite fully and, in particular, Terman in his "Radio Engineer's Handbook" (1st edition, 1943, pp. 154–172) gives a very full treatment, including a consideration of those cases in which the pass-band is an appreciable fraction of the mean frequency and those in which the degrees of damping in the two circuits are unequal.

It is not intended to deal with this subject in this present article but, in order to emphasize the differences between the sucker circuit and the conventional arrangement, it may be useful to re-state a few of the general results as follows:—

(*a*) The conventional circuit is normally used where a fairly flat-topped response curve, in conjunction with rapid attenuation outside the pass-band, is needed. The coupling coefficient, therefore, is usually adjusted to a value between a third and three times the critical value.

(*b*) The response curve is double-humped if the coupling exceeds the critical value.

(*c*) If the pass-band is a fairly small fraction of the mean frequency and there are no stray reactions round the amplifier valves, the response curve is symmetrical provided that *either* the two resonant circuits are tuned to the same frequency *or* the two circuits have the same magnification factor. An asymmetrical curve can only result if the circuits differ in both respects.

(*d*) The circuit is difficult to tune by simple methods if the coupling exceeds about 0.7 of the critical value, because of the interaction of the two resonant circuits.

(*e*) The response curve cannot show a sudden trough of attenuation over a frequency band which is narrow compared with the pass-band.

(*f*) In the region of the skirts the response curve is twice as steep as that of a single circuit, and the phase-change of sidebands relative to a central carrier is 180 degrees. The phase changes rapidly at the limits of the pass-band with the

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result that these circuits can only be used with caution in television applications.

(*g*) All the symmetrical cases can be considered, mathematically, in terms of quadratic expressions and can therefore be accurately examined with complete generality.

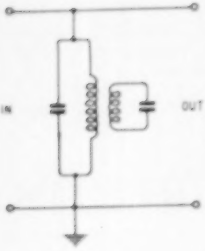


Fig. 1. *Mutual-inductance coupling.*

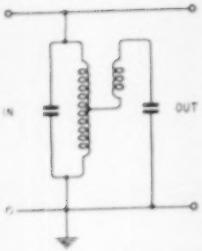


Fig. 2. *Tapped-primary circuit.*

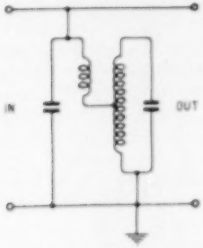


Fig. 3. *Tapped-secondary circuit.*

Absorption Circuit

This name is given to any arrangement in which the input and output connections are taken to the same resonant circuit, and a second circuit is coupled to the first so as to absorb power at some specific frequency. This second circuit may be used to broaden and flatten the response curve of the primary circuit or to make a deep trough at, say, the frequency of an unwanted signal without interfering unduly with the transmission of a wanted signal.

The most common circuit arrangements are shown in Figs 1–3, in which coupling is achieved by means of mutual or common inductance. Capacitance-coupling can, of course, be used, but it is less desirable owing to the fact that an extra component is necessary. In addition, the value of the capacitor, which is required in the case of 'top coupling,' may be inconveniently low. The behaviour of the capacitance-coupled circuit does not differ significantly from that of the circuit with inductance coupling, provided that the pass-band is comparatively narrow.

In order to contrast the chief features of the absorption or sucker circuit with those of the normal type, they may be summarized, in general and qualitative terms, as follows :—

(*a*) The sucker circuit can be used to give a fairly flat-topped response curve without a particularly steep slope outside the pass-band. In this case the coupling coefficient is usually rather less than the critical value. Alternatively, the circuit may be used to attenuate a particular narrow band of frequencies, and for this application a considerably higher value of the coupling coefficient is required.

(*b*) When the circuit is used to give a response curve which is flat in the pass-band, double humps develop if the coupling coefficient exceeds half the critical value. When it is used for absorption, the depth of the attenuating trough varies with the coupling coefficient, but the effect on the shape of the curve depends to a major extent on the relationships between magnification factors, coupling, and detuning, as will be described later.

(*c*) If the two circuits are tuned to the same frequency, the curve will be symmetrical for reasonably narrow pass-bands, whatever the values of the magnification factors may be. Equal magnification factors do not, however, give a symmetrical response curve under any other conditions.

(*d*) In general, the sucker circuit is very much easier to adjust than the normal band-pass circuit because, in the matter of tuning, the resonant circuits are more independent of one another.

(*e*) If the magnification factor of the secondary circuit is considerably higher than that of the primary circuit, the trough will be narrow in comparison with the pass-band.

(*f*) In the region of the skirts, the same value of attenuation is given by the whole circuit as by the primary circuit alone, so that the corresponding phase-change is only 90 degrees. The phase also changes fairly rapidly with change of frequency near the trough, but as there are presumably no wanted frequency components of importance very close to the trough, the circuit is still suitable for television use.

(*g*) Except in the case in which both the resonant circuits are tuned to the same frequency, the equivalent mathematical expressions develop to at least a cubic form and they cannot therefore be interpreted in completely general terms. For this reason the main part of the text which follows is concerned with approximations and graphical illustrations only.

Analysis

The circuit is most conveniently analysed from the starting point of Fig 4, which indicates the reactive components L_1 and C_1 and the loss resistance r_1 of the primary and L_2, C_2, r_2 of the secondary circuits. The following discussion is, however, more conveniently undertaken in terms of X_1 (the reactance of L_1 or C_1 at their present resonant frequency $\omega_1/2\pi$), and similarly for X_2, and the dimensionless expressions

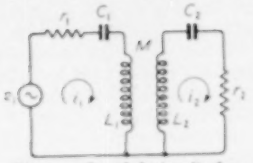


Fig. 4. *Coupled circuits for analysis.*

$\beta_1 = r_1/X_1$ (the reciprocal of the magnification factor)

and $\psi_1 = \dfrac{\omega}{\omega_1} - \dfrac{\omega_1}{\omega}$ (the 'detuning' factor)

so that the total series impedance z_1 of the primary circuit

$$z_1 = r_1 + j\omega L_1 + 1/j\omega C_1$$

can be written

$$X_1\left(\frac{r_1}{X_1} + j\frac{\omega L_1}{\omega_1 L_1} - j\frac{\omega_1 C_1}{\omega C_1}\right)$$

$$= X_1(\beta_1 + j\psi_1) \quad .. \quad .. \quad .. \quad (1)$$

Identical expressions with the suffix 2 in place of 1, will be used to signify the same quantities

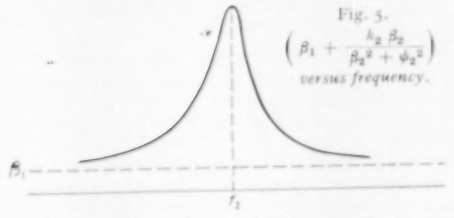


Fig. 5. $\left(\beta_1 + \dfrac{k_2\beta_2}{\beta_2^2 + \psi_2^2}\right)$ *versus frequency.*

in the secondary circuit, leading to the corresponding expression

$$z_2 = X_2(\beta_2 + j\psi_2) \quad .. \quad .. \quad .. \quad (2)$$

Internal Impedance

Now, analysing the two circuits when they are coupled together, in the manner of Fig 4, with a mutual reactance $\omega M \approx k\sqrt{X_1X_2}$ we can write, for the first mesh,

$$e_1 = i_1X_1(\beta_1 + j\psi_1) + i_2jk\sqrt{(X_1X_2)} \; .. \quad (3)$$

and for the second mesh

$$0 = i_1jk\sqrt{(X_1X_2)} + i_2X_2(\beta_2 + j\psi_2) \; .. \quad (4)$$

Eliminating i_2, we obtain an expression for the internal impedance, viz. :

$$\frac{i_1}{e_1} = X_1\left\{\beta_1 + j\psi_1 + \frac{k^2}{\beta_2 + j\psi_2}\right\} \quad .. \quad (5)$$

External Conductance

In practice, of course, the circuit is not driven by a low-impedance generator in series with L_1 and C_1, but by a high-impedance (approximately constant-current) source in parallel with C_1. In this case the input current I_1 which is needed to produce the same internal currents is given very closely by

$$I_1 = je_1/X_1 \quad .. \quad .. \quad .. \quad .. \quad (6)$$

and the output voltage E_1, taken across C_1, by

$$E_1 = ji_1X_1 \quad .. \quad .. \quad .. \quad .. \quad (7)$$

so long as ω is in the region of ω_1, and the magnification factor is high.

Hence $$\frac{X_1I_1}{E_1} = \frac{e_1}{i_1X_1} \quad .. \quad .. \quad .. \quad (8)$$

and the ratio of the conductance of the whole circuit I_1/E_1 to that of the individual primary reactance $1/X_1$ can be expressed, using equation (5), as

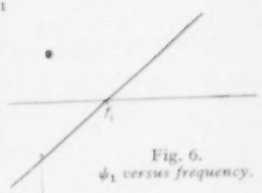


Fig. 6. ψ_1 *versus frequency.*

$$\beta_1 + j\psi_1 + \frac{k^2}{\beta_2 + j\psi_2} \quad .. \quad .. \quad .. \quad (9)$$

This dimensionless expression provides the most suitable means by which the circuit may be examined in general terms. When the circuit is fed as described from a high-impedance (constant-current) source, the response curve is given by the reciprocal of the modulus of expression (9).

To obtain this modulus, the expression (9) must be rewritten in the form

$$\beta_1 + j\psi_1 + \frac{k^2(\beta_2 - j\psi_2)}{\beta_2^2 + \psi_2^2}$$

$$\text{or } \left\{\beta_1 + \frac{k^2\beta_2}{\beta_2^2 + \psi_2^2}\right\} + j\left\{\psi_1 - \frac{k^2\psi_2}{\beta_2^2 + \psi_2^2}\right\} \; .. \quad (10)$$

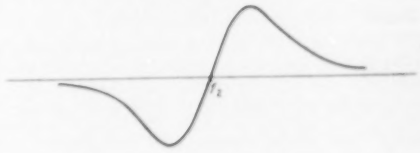


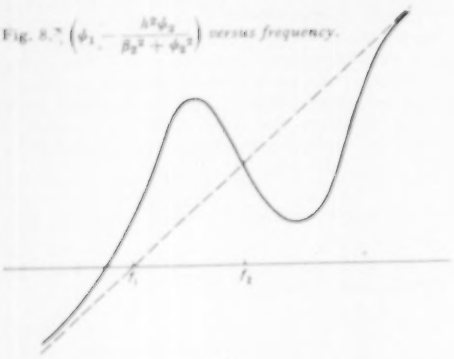
Fig. 7. $\left(\dfrac{k^2\psi_2}{\beta_2^2 + \psi_2^2}\right)$ *versus frequency.*

and the square of the modulus is obtained by squaring and adding the two expressions in the brackets.

Figs 5–8 show the general behaviour of the

separate components of expression (10) in the region of f_1 and f_2, the tuned frequencies of the two circuits.

Fig. 8. $\left(\psi_1 - \frac{k^2\psi_2}{\beta_2^2 + \psi_2^2}\right)$ *versus frequency.*



β_1 is constant. $\frac{k^2\beta_2}{\beta_2^2 + \psi_2^2}$ rises to a maximum value of k^2/β_2 when $\psi_2 = 0$ [i.e., at the frequency f_2 $(\omega_2/2\pi)$] and falls to low values at frequencies which are remote from f_2. The behaviour of the sum of the terms in the real bracket of expression (10) is thus represented by Fig 5.

If F represents the mean frequency, then, in the region under consideration, ψ_1 is approximately equal to $2(f - f_1)/F$ and can be represented by a straight line with a slope of $2/F$ crossing the axis at the frequency $f_1 = \omega_1/2\pi$. This is shown in Fig 6.

The value of the term $\frac{k^2\psi_2}{\beta_2^2 + \psi_2^2}$ can be represented by a curve which crosses the axis at the frequency f_2 with a slope of $\frac{k^2}{\beta_2^2} \cdot \frac{2}{F}$. This curve passes through extreme values, $\pm k^2/2\beta_2$, when $\psi_2 = \pm \beta_2$ and returns asymptotically to the axis as shown in Fig 7. The difference between these terms, viz.: $\psi_1 - \frac{k^2\psi_2}{\beta_2^2 + \psi_2^2}$ is represented in Fig 8.

By squaring and adding the ordinates of the curves in Figs 5 and 8, a curve is obtained which represents the square of the attenuation of the circuit under consideration. This curve is shown in Fig 9.

Tuning Effects

At any frequency f, the effect of tuning the primary circuit alone can be examined by varying ψ_1 alone in the mathematical expressions. Similarly, the result of adjusting the secondary can be examined by varying ψ_2 alone. Since $(\psi_1 - \psi_2)$ is approximately equal to

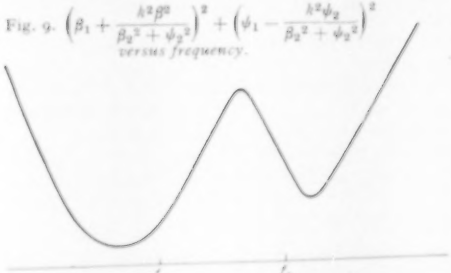
$$2 \cdot \frac{f - f_1}{F} - 2 \cdot \frac{f - f_2}{F} = \frac{2(f_2 - f_1)}{F},$$

the shape of the response curve can be calculated by varying ψ_1 and ψ_2 together in such a way as to keep $(\psi_1 - \psi_2)$ constant.

If we tune the secondary to give minimum primary response at a certain frequency f_{min}, the equivalent mathematical operation involves finding the value of ψ_2 which gives the maximum modulus in expression (10). Now the real component of this expression has a maximum at $\psi_2 = 0$, and the imaginary component a maximum at $\psi_2 \approx -\beta_2$. The greatest modulus will occur at a value of ψ_2 between these limits. If β_2 is small, as is usual when the circuit is used to eliminate unwanted signals, the required tuning point of the secondary circuit is very close to the frequency f_{min}, and it depends only to a small degree on the setting of the primary frequency f_1. The complete expression for ψ_2 at maximum attenuation is a cubic, which is not directly intelligible.

The consideration of the frequency to which the primary circuit must be tuned in order to give maximum response at a certain frequency f_{max} is much easier. ψ_1 does not appear in the real part of expression (10) so that the modulus has a minimum value when the imaginary part vanishes.

Fig. 9. $\left(\beta_1 + \frac{k^2\beta_2}{\beta_2^2 + \psi_2^2}\right)^2 + \left(\psi_1 - \frac{k^2\psi_2}{\beta_2^2 + \psi_2^2}\right)^2$ *versus frequency.*

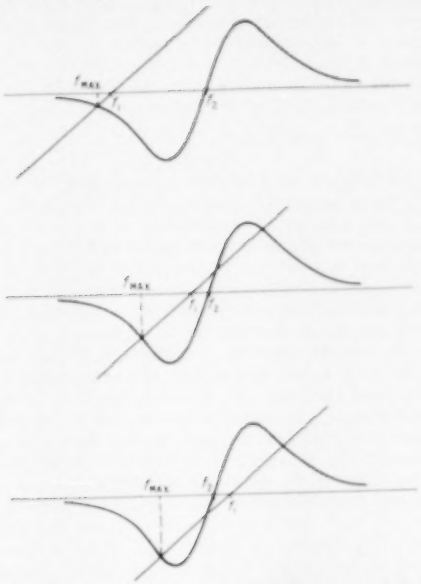


The effect in this case is best studied by superimposing the curve of Fig 6 on that of Fig 7, as shown in Figs 10–12. The position, relative to the curve of the line representing ψ_1 (which cuts the axis at a frequency f_1) varies with the frequency to which the primary circuit is tuned. The points at which the line intersects the curve correspond to the values of the frequency for which the imaginary part of expression (10) vanishes.

Shape of Response Curve

Three cases which differ qualitatively can occur. In the first case, the line ψ_1 only intersects the

other curve at one point, and this represents the frequency f_{max}. In the other two cases there are three intersections.



Figs. 10-12. *Superimposition of curves of Figs. 6 and 7.* Fig. 10 (top) *one intersection point only;* Fig. 11 (centre) f_1 *between* f_{max} *and* f_2; *and* Fig. 12 (bottom) f_1 *on side of* f_2 *remote from* f_{max}.

In the first case there will be little difference between f_1 and f_{max}, which means that the peak will be close to the resonant frequency of the primary. Although the reactive component of expression (10) does not fall to zero at any other point, it does dip temporarily where the curves approach one another, but the frequency at which this occurs is so near to f_2 that the real part has quite a high value and the attenuation is still substantial. The presence, therefore, of the secondary circuit produces a trough, which is flanked by a slight peak, on the side of the response curve. This is illustrated in Fig 13.

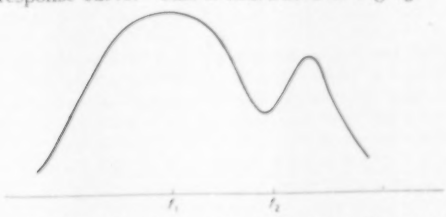


Fig. 13. *Response curve corresponding to Fig. 10.*

The first case merges into the second approximately when the frequency f_1 is such that the line ψ_1 passes through the peak of the other curve. The peak ordinate of the curve has a value $k^2/2\beta_2$ and therefore ψ_1 must be equal to $k^2/2\beta_2$ at this frequency. The transition thus occurs approximately when

$$f_{max} \sim f_{min} = \frac{F}{2} \cdot \frac{k^2}{2\beta_2} \quad .. \quad .. \quad (11)$$

Taking a particular case, if $k = 0.1$, $\beta = 0.01 = k^2$ and $F = 60$ Mc/s, the transition will occur when the separation of f_{max} and f_{min} is 15 Mc/s.

In the second case the line ψ_1 cuts the other curve in three points, and it cuts the axis on the same side of f_2 as f_{max}. Here the imaginary part of expression (10) falls to zero at two other points besides f_{max}, but at one (the nearest to f_2) the real component is large and so there is not a third hump on the response curve. At the third point the real component is not as large, but it is greater than at f_{max}, so that the hump at this third point will not be as high as that at f_{max}. This is illustrated in Fig 14.

In the third case, the line ψ_1 again cuts the other curve in three points, but it cuts the axis on the other side of f_2. The response curve is now the mirror image of that which arose in the second case, the small peak occurring at f_{max} and the larger peak on the far side of the trough.

These two cases merge when there is symmetry and $f_1 = f_2$. Here, if ψ denotes the common value of ψ_1 and ψ_2, we find that

$$\psi^2 = k^2 - \beta_2^2$$

and that, if k is at all large compared with β_2,

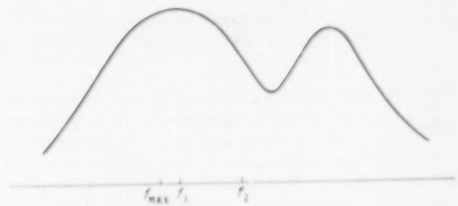


Fig. 14. *Response curve corresponding to Fig. 11.*

ψ is closely equal to k, and

$$f_{max} \sim f_{min} = \frac{kF}{2}$$

In a particular case, if $k = 0.1$, and $F = 60$ Mc/s, the transition will occur when the spacing between f_{max} and f_{min} is 3 Mc/s.

If, therefore, an attempt were made to tune the primary for maximum response at a frequency nearer to f_{min} than that determined by the above expression (within 3 Mc/s in the particular case quoted), it would only result in a response curve with a small peak near f_{max}, the larger peak

being spaced well away on the far side of the trough.

Depth and Shape of Trough

The response at the peak is controlled mainly by β_1. The response at the trough is controlled by k^2/β_2 and the relative depth of the trough is therefore approximately $k^2/\beta_1\beta_2$. This, however, is only true up to a point because, as soon as k^2/β_2 becomes comparable with unity, the phase angle of the loaded inductance approaches

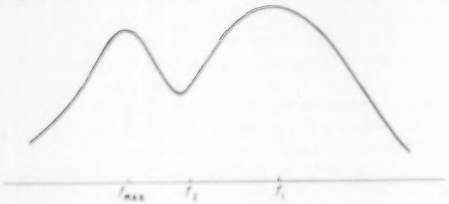


Fig. 15. *Response curve corresponding to Fig. 12.*

45 degrees, and the transference of further damping has little effect. The maximum value that can be obtained for the relative depth of the trough is therefore $1/\beta_1$ (which is equal to Q_1).

The width of the trough at its greatest depth is determined by β_2 only (provided that the limiting effect of the last paragraph is not reached), and hence the width of the band of frequencies attenuated is $F\beta_2$. The total width over which the trough affects the shape of the curve is determined by equality between the terms β_1 and $k^2\beta_2/\psi_2^2$, and hence the separation between the shoulders of the trough can be shown to be $Fk\sqrt{(\beta_2/\beta_1)}$ or alternatively

$$F\beta_2\left(\frac{k^2}{\beta_1\beta_2}\right)^{\frac{1}{2}}$$

This latter form of the expression shows that the ratio between the widths of the trough at the bottom and at the shoulders is equal to the square root of the attenuation obtained.

Using the concrete figures assumed in previous examples, the attenuation ratio is 10 to 1 (20 db). The width of the trough is 0.6 Mc/s at the bottom, and nearly 2.0 Mc/s at the shoulders.

The width at the shoulders increases with $\sqrt{k^2/\beta_1\beta_2}$, even when the attenuation is not obtained because of the 'saturation effect' mentioned. As this extra width is usually harmful, it is best in practice to limit k^2/β_2 to about 0.5 in order to get the maximum attenuation that can be obtained without giving rise to wasteful broadening at the top of the trough.

SPIRAL TIME BASE

Magnetic and Electric Deflection

This note describes some work carried out by the Radar Research and Development Establishment in 1939 and described, together with other features of a particular radar set, in British Patent No. 582,419.

THE basic circuit for a discontinuous spiral time base for a cathode-ray tube is shown in idealized form in Fig. 1. The deflector coils, each of inductance L, are used also as the inductances of the tuned circuit which gives electrical quadrature automatically and can easily be adjusted to give mechanical quadrature.[1]

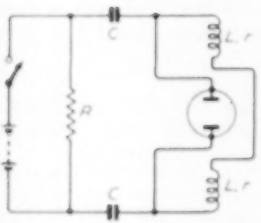


Fig. 1. *Basic circuit of spiral time base.*

The values of L and C are chosen to resonate at the required frequency of rotation of the time base and the series resistance r of the coils is kept small. The resistance R is made equal to $2L/C$, the value giving critical damping of the circuit.

When the switch is closed there is an extremely short transient period during which stray capacitances are charged, but not the main capacitance of the oscillatory circuit. After this there is a free damped oscillation in the tuned circuit and it has a period which is determined solely by L and C. Neglecting the effect of the series resistance r of the deflector coils, which is small, the current in the coils is 90° out of phase with the voltage across them. As shown in Fig. 1 the magnetic deflection is at 90° to the electric and so it is only necessary to make the amplitudes of the two equal in order to obtain a truly

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"circular" rotation of decreasing amplitude. With the connections shown the waveform of Fig. 2 (a) is drawn on the screen of the c.r. tube without having to adopt any special biasing arrangements.

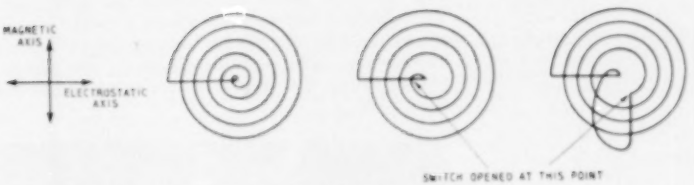
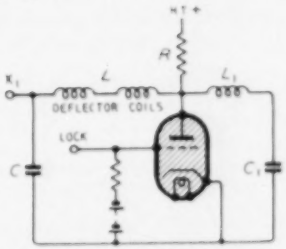


Fig. 2 (left). *Forms of trace given by the circuit of Fig. 1; (b) and (c) illustrate the effect of opening the switch at different points of the cycle.*

Fig. 3 (below). *Simple equivalent of Fig. 1 using a thyratron as a switch.*



Now let the switch be opened after the circuit has made four oscillations. At this instant there is energy stored in the electric fields of the capacitors and the magnetic fields of the coils. The relative amounts of each depends on the part of the cycle at which the switch is opened. However, whatever the prevailing conditions, the critical damping imposed by R ensures that nearly all the energy is dissipated in about one cycle. Once this cycle has been completed there is no energy left anywhere in the system and the process is truly a discontinuous one. The traces obtained when the switch is opened at two different parts of a cycle are shown in (b) and (c) of Fig. 2.

One of the simplest circuits for carrying out the switching action is shown in Fig. 3 but it has the disadvantage for some applications of needing a thyratron valve. The circuit L_1C_1 supplies current to keep the thyratron conductive during the back swing of voltage across LC. It is tuned to $\frac{1}{8}$th of the frequency of LC and controls the number of turns in the spiral trace.

The basic circuit employed for radar purposes is shown in Fig. 4 and various waveforms in the circuit are illustrated in Fig. 5. A multivibrator, comprising V_1 and V_2, feeds a pulse of standard duration to V_3 and is locked by a rectified pulse from the radar transmitter. This locking pulse is shown in Fig. 5(a) and the standard pulse in the output of V_3 in (b). The valves V_6 and V_7 form a cathode-follower so that this waveform can appear at low impedance at point A in Fig. 4. The impedance is only $1/2g_m$ where g_m is the mutual conductance of each of the two valves. The square wave appearing across

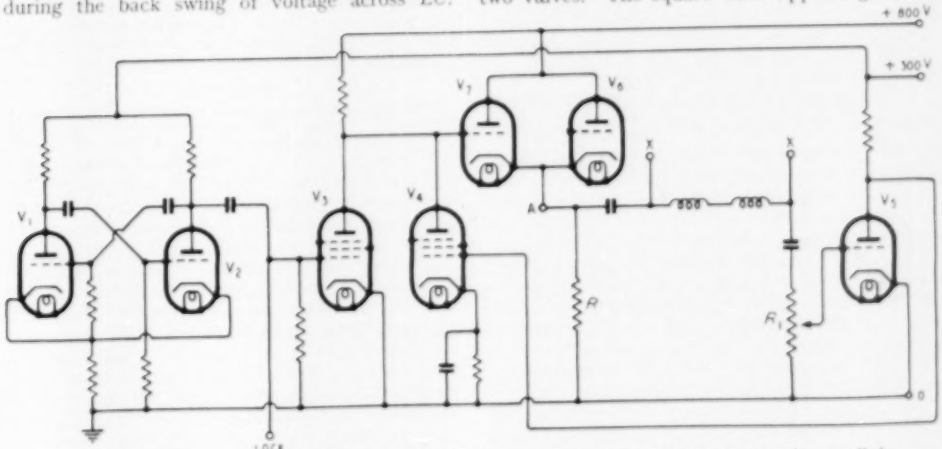


Fig. 4. *Elaborate switch circuit including a feedback circuit with which the coil resistance can be cancelled.*

an impedance $1/2g_m$ acts in this circuit as the equivalent of the switch of Fig. 1.

A feedback circuit is provided with V_4 and V_5. A voltage is derived from the resistance R_1 in series with the tuned circuit, amplified

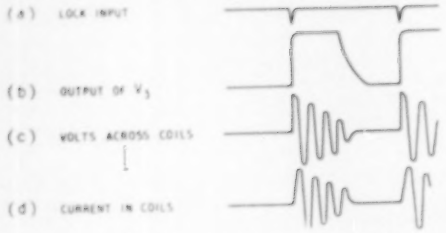


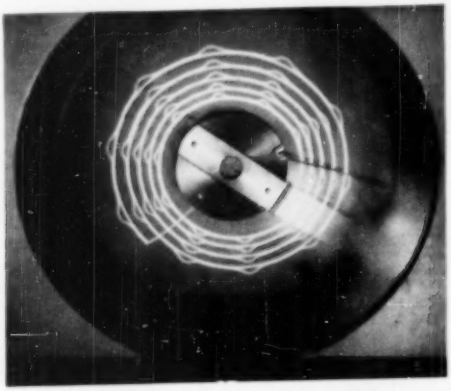
Fig. 5. *Waveforms in the circuit of Fig. 4.*

Fig. 6. *Example of the kind of trace obtainable with the circuit of Fig. 4.*

and fed back to the "top-end" of the series-resonant circuit. If there is unity gain in the amplifier V_4, V_5 and there is no phase shift the two voltages exactly cancel.

A small increase in the gain enables the effect of the resistance of the coils to be cancelled, while still greater gain results in a spiral trace increasing outwards. This is a stable condition and the transition from the inward spiral to the outward is quite smooth. The various forms of trace obtainable are shown in Fig. 6. In some equipment a modified feedback circuit was used and also a method of stabilizing the amplitude of the trace. These later developments do not affect the general operation, however.

When deflecting the trace radially it is of no advantage to obtain a greater deflection than that needed to fill the space between the turns of the spiral. Any system which will do this is adequate, therefore. The method adopted in the radar equipment for which this spiral time base was designed was to apply the deflecting signal to a metal-plate fixed to the front of the tube and to rely on the field between this plate and the final anode to produce the deflection. This method may seem somewhat crude but it works and proved quite suitable for the particular application. The plate is visible in the photograph, which also shows the spiral trace and its deflection.



Radial deflection of the trace is obtained by applying the signal to a metal plate fixed to the screen of the c.r. tube.

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REFERENCE

1. "A New Polar Co-ordinate Cathode-Ray Oscillograph with Extremely Linear Time Scale," by Manfred von Ardenne, *The Wireless Engineer*, January 1937, p. 5.

THE SYNCHRODYNE AS A PRECISION DEMODULATOR

By D. G. Tucker* and R. A. Seymour

(*Post Office Research Station*)

SUMMARY.—Demodulating systems in which the modulation frequency is extracted by filtration *following* the demodulator or detector have advantages over the conventional systems in that the difficult problem of narrow-band h.f. filtration is avoided. When unwanted signals of high level are liable to be present, ordinary detectors cannot be used without preliminary filtration, so that systems of the synchrodyne, homodyne or exalted-carrier types are necessary.

The use of the synchrodyne system is described here for applications where a high degree of precision is required ; i.e., where special requirements of low harmonic distortion, constant gain to the modulation-frequency component, etc., exist. It is shown that some measure of control of the phase angle of the local oscillation relative to the incoming carrier is necessary, and that the phase-shifts in various parts of the circuit must be carefully considered and restricted.

Following an analysis of the distortion produced by phase errors, suitable circuits for controlling the phase angle of the local oscillation and for reducing stray phase errors are described.

List of Symbols

θ = phase angle between injected synchronizing signal and the forced oscillation at the same point in the oscillator.

θ' = phase angle as above when modulated due to the a.m. on the injected signal. (N.B. θ' is a time function).

ϕ = stray phase-shifts such that the phase angle between input to the main modulator and the switching signal is $\phi + \theta$.

e_s = injected-signal voltage.

e_i = forced-oscillation voltage.

p (as subscript) = pull-out value.

ω_a = modulation angular frequency.

ω_s = carrier angular frequency of input signal.

ω_N = natural angular frequency of oscillator.

$x = \omega_s/\omega_N$.

m = depth of modulation.

$J_n(a)$ = Bessel function of the first kind, of order n and argument a.

E = amplitude of input signal.

Other symbols used only in one place are defined as they occur.

1. Introduction

THE method of demodulating amplitude-modulated signals known as the 'synchrodyne' is a development of the homodyne method, which is relatively old, having apparently been first published by Colebrook[1] in 1924. In its early form the homodyne consisted merely of a self-oscillating detector, the oscillations being synchronized to the incoming-carrier frequency. Only poor-quality demodulation is obtainable by this method, but a series of patent specifications[3–7] during the thirties detailed improvements which made the system quite satisfactory for many purposes. An article[2] in 1942 outlined the benefits which would be obtained if a really satisfactory homodyne system could be designed. The synchrodyne in its most developed form probably is such a system. Most of its possibilities as a radio receiver have been fully discussed in publications, of which the full list is very long ; but those given here[8–15] appear to make some significant contribution to the development of the subject. Another application, of much less popular interest, but much more severe in its performance requirements, is to highly-selective transmission-measuring equipment[16, 17] which is required to measure the voltage level of the sidebands of a test-tone modulated at say 33 c/s and transmitted in the narrow gaps between channels in a multi-channel carrier telephone system.

The synchrodyne process, in its simplest form, is illustrated in Fig. 1. A local oscillator is tuned to a frequency close to that of the a.m. signal required to be demodulated, and is actually synchronized to its carrier by the injection of a suitable amount of the signal into the oscillator circuit. The mechanism of this process, and of the discrimination of the circuit which results in the output of the oscillator being a relatively pure tone, free of the sidebands and interfering signals, is described in earlier publications[18–20]. The output of this oscillator is used as the switching signal of a switching-type modulator to the input of which is applied the a.m. signal. The output contains, among other products which can easily be filtered out, the original modulation-frequency signal. The important point is that no filtration is necessary before demodulation provided that the main transmission path has a linear response, all selectivity and discrimination against other signals being vested in the synchronized oscillator and in the low-pass filter in the output circuit. The frequency-response of the

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wanted signal need not be impaired by demodulation except in so far as the low-pass filter departs from an ideal response (which need be very little) or has to cut-off below the upper frequency-limit of the required signal owing to overlapping by other signals. This has been adequately discussed in earlier works. The only other distortions to which the demodulated signal is liable are nonlinear ones due to the output of the local oscillator being phase-modulated at the modulation frequency. These affect both applications of the system as will be clear later. These distortions have been largely ignored in earlier works, and the subject of the first part of the present paper is to analyse them in the basic circuit. The second part discusses the circuit arrangements by which the system can be made a demodulator of real precision, of stability and with freedom from distortion.

2. Basic Distortion in a Synchrodyne Demodulator

2.1 *Strict Analysis for Small Depth of Modulation**

In a synchrodyne demodulator distortion arises due to the output of the synchronized oscillator becoming phase-modulated at the modulation frequency of the incoming signal. This occurs because the locking tone is amplitude modulated, and because when the natural frequency of the oscillator is not the same as the forced-oscillation frequency there is a phase angle (θ) between the locking tone and the forced oscillation at the point of injection. This phase angle is given by the equation

$$\sin\theta \approx \frac{1-x}{1-x_p} \qquad \ldots \qquad \ldots \qquad \ldots \qquad (1)$$

where x is the ratio ω_s/ω_N; ω_N = natural angular frequency; ω_s = locking frequency and p signifies the value at pull-out.

The synchronized range $(1 - x_p)$ is given by

$$1 - x_p = e_s/2e_iQ \qquad \ldots \qquad \ldots \qquad \ldots \qquad (2)$$

where e_s = injected (locking) signal,

e_i = forced-oscillation amplitude at point of injection

Q = effective Q of oscillator tuned circuit.

Thus for fixed natural and synchronized frequencies

$$\sin\theta \propto 1/e_s \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (3)$$

If the injected locking signal is amplitude-modulated (as it is in the synchrodyne demodulator), then e_s is varying at the modulation frequency, so that $\sin\theta$ also varies; i.e., the oscillator is phase-modulated. If we ignore the larger values of θ, which occur towards the edges of the synchronizing range, then $\sin\theta \approx \theta$ so that $\theta \propto 1/e_s$, and if we assume the depth of modulation is small, then we may regard the phase modulation as sinusoidal; i.e., the phase angle in the oscillator is

$$\theta' = \theta - m\theta\cos\omega_0 t \qquad \ldots \qquad \ldots \qquad \ldots \qquad (4)$$

where m = depth of modulation of a.m. signal and ω_0 = angular frequency of modulation.

The output of the oscillator is used as the switching signal on a modulator, the input of which is the main a.m. signal,

$$E\cos\omega_s t.\,(1 + m\cos\omega_0 t) \qquad \ldots \qquad \ldots \qquad (5)$$

Let the circuit phase-shift additional to that due to the locking of the oscillator be ϕ so that the phase angle between switching signal and input signal at the modulator is $\phi + \theta - m\theta\cos\omega_0 t$. Then the output of the modulator is, apart from a constant numerical factor,

$$E\cos\omega_s t.\,(1 + m\cos\omega_0 t).\cos(\omega_s t + \phi + \theta - m\theta\cos\omega_0 t) \qquad \ldots \qquad (6)$$

$$= E\cos\omega_s t.\,(1 + m\cos\omega_0 t).\,[J_0(m\theta)\cos(\omega_s t + \phi + \theta) + 2J_1(m\theta)\sin(\omega_s t + \phi + \theta).\cos\omega_0 t - 2J_2(m\theta)\cos(\omega_s t + \phi + \theta).\cos 2\omega_0 t + \ldots] \qquad \ldots \qquad (6a)$$

$$= E\Big[J_0(m\theta)\Big\{\tfrac{1}{2}\cos(2\omega_s t + \phi + \theta) + \underline{\tfrac{1}{2}\cos(\phi + \theta)} + \frac{m}{2}\cos(2\omega_s t + \phi + \theta).\cos\omega_0 t + \underline{\frac{m}{2}\cos(\phi + \theta).\cos\omega_0 t}\Big\} + J_1(m\theta).\Big\{\sin(2\omega_s t + \phi + \theta).\cos\omega_0 t + \underline{\sin(\phi + \theta).\cos\omega_0 t} + m\sin(2\omega_s t + \phi + \theta)\cos^2\omega_0 t + \underline{\frac{m}{2}\sin(\phi + \theta)} + \underline{\frac{m}{2}\sin(\phi + \theta).\cos 2\omega_0 t}\Big\} - J_2(m\theta)\Big\{\cos(2\omega_s t + \phi + \theta).\cos 2\omega_0 t + \underline{\cos(\phi + \theta).\cos 2\omega_0 t} + m\cos(2\omega_s t + \phi + \theta).\cos\omega_0 t.\cos 2\omega_s t + \underline{\frac{m}{2}\cos(\phi + \theta).\cos\omega_0 t} + \underline{\frac{m}{2}\cos(\phi + \theta).\cos 3\omega_0 t}\Big\} + \text{etc.}\ldots\Big]$$

* The case of large depth of modulation is discussed in reference 26.

Significant terms are underlined in the foregoing expansion. After filtering-off all h.f. components, we are left with the underlined terms, which may be rearranged thus :—

$$\frac{1}{2}E\left[\cos(\phi+\theta)\,.\,J_0(m\theta)+m\sin(\phi+\theta)\,.\,J_1(m\theta)\right]$$
$$+E\left[\frac{m}{2}\cos(\phi+\theta)\,.\,\{J_0(m\theta)-J_2(m\theta)\}+\sin(\phi+\theta)\,.\,J_1(m\theta)\right]\cos\omega_0 t$$
$$+E\left[\frac{m}{2}\sin(\phi+\theta)\,.\,J_1(m\theta)-\cos(\phi+\theta)\,.\,J_2(m\theta)\right]\cos 2\omega_0 t$$
$$-E\left[\frac{m}{2}\cos(\phi+\theta)\,.\,J_2(m\theta)\right]\cos 3\omega_0 t \qquad (7)$$

assuming that $J_3(m\theta)$ and higher orders are negligible, which is true for values of θ in the range we are concerned with.

If there were no phase errors or phase modulation the output would be merely

$$\frac{Em}{2}\cos\omega_0 t \qquad (8)$$

with a d.c. term of $E/2$.

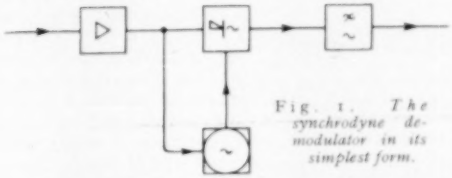

Fig. 1. *The synchrodyne demodulator in its simplest form.*

The remainder of the terms represent some form of distortion, according to the application of the circuit. For instance, in a synchrodyne radio receiver, the variation of the level of the fundamental frequency is relatively unimportant, but the introduction of harmonics of the modulation frequency is a serious form of distortion which will become detectable to the ear if of sufficient magnitude. On the other hand, in the synchrodyne demodulator of a highly-selective transmision-measuring equipment, the harmonics are unimportant since they are filtered off, but variations in the level of the fundamental are direct errors in measurement.

The distortion described in this section has been called 'basic distortion' because it is fundamental to the synchrodyne circuit and is not due to practical imperfections. The only way of keeping it within desired limits is to control the phase angles as much as necessary. Thus, in the transmission-measuring equipment, an automatic phase-control circuit has been added.

We have here assumed that the depth of modulation is small. The modifications necessary when m is not small are comparatively minor.

2.2 *Simplified Analysis*

The analysis of the previous section does not greatly assist the physical understanding of the distortion effect, and in view of the restrictive assumptions made that $m \ll 1$ and $\sin\theta \approx \theta$, there is some justification for a cruder method of analysis that does illustrate how the distortion arises.

In the absence of the phase-modulation effect the output of the modulator includes (before it is filtered) the d.c. and modulation-frequency components ; thus

$$\frac{E}{2}\left[\cos(\phi+\theta)+m\cos(\phi+\theta)\,.\,\cos\omega_0 t\right]$$

With the phase-modulation of depth $m\theta$, these terms fluctuate between

$$\frac{E}{2}\left[\cos(\phi+\theta-m\theta)+m\cos(\phi+\theta-m\theta)\cos\omega_0 t\right]$$

and

$$\frac{E}{2}\left[\cos(\phi+\theta+m\theta)+m\cos(\phi+\theta+m\theta)\cos\omega_0 t\right]$$

Thus we have a fluctuation of the d.c. component of peak-to-peak amplitude

$$\frac{E}{2}\left[\cos(\phi+\theta-m\theta)-\cos(\phi+\theta+m\theta)\right]$$

i.e., $E\sin(\phi+\theta)\,.\,\sin m\theta$

at frequency ω_0, and also a fluctuation of the amplitude of the component of frequency ω_0 of m times this amount at frequency ω_0. The first introduces mainly an additional output of modulation frequency, and the second introduces second harmonic of the modulation frequency. There is also an additional second-harmonic component due to the lack of symmetry of the first fluctuation term. Fig. 2 illustrates the process.

We may assume, as a first approximation, that the peak-to-peak amplitude of the fluctuations represents the fundamental components, and that half the difference between the positive fluctuation on one half-cycle and the negative fluctuation on the other represents the second-harmonic components. We thus arrive at the following expression for the output, putting $\sin m\theta \approx m\theta$, and regarding the signs of the various terms,

$$\frac{Em}{2}\left[\cos(\phi+\theta).\cos m\theta+\theta\sin(\phi+\theta)\right]\cos\omega_0 t$$
$$+\frac{E}{2}\left[\frac{m^2}{2}\theta\sin(\phi+\theta)-\cos(\phi+\theta).(1-\cos m\theta)\right]\cos 2\omega_0 t$$
$$-\frac{Em}{2}\left[\cos(\phi+\theta).(1-\cos m\theta)\right]\cos 3\omega_0 t \quad .. \quad .. \quad .. \quad (9)$$

This expression is actually a very good approximation to that developed more formally using Bessel functions; it is identical if we put

$J_0(m\theta) \approx 1$
$J_1(m\theta) \approx \frac{1}{2} m\theta$
$J_2(m\theta) \approx (1-\cos m\theta)$

The first two are quite acceptable approximations, since the usual approximations for small arguments are

$$\left.\begin{aligned} J_0(m\theta) &\approx 1-\frac{(m\theta)^2}{4} \\ J_1(m\theta) &\approx \tfrac{1}{2} m\theta \\ J_2(m\theta) &\approx \tfrac{1}{8}(m\theta)^2 \end{aligned}\right\} \quad .. \quad .. \quad .. \quad (10)$$

Unfortunately $1-\cos m\theta \approx \frac{1}{2}(m\theta)^2$ so that there is an error in all the frequency components given by the approximate formula, but the amplitude of this term in question is very small, and is again modified if m is not small compared with unity, due to the unsymmetry of the phase modulation itself.

2.3 *Numerical Results*

The variation of amplitude of the d.c., fundamental, and 2nd and 3rd harmonic components, as given in equation (7), is conveniently plotted against θ, for each of a small number of values of ϕ. Figs. 3–5 give these relationships. Fig. 3(a) shows the resultant output of fundamental modulation frequency, and it can be seen that errors in θ increase the output, while errors in ϕ decrease it. Noting the very enlarged output scale, it can be seen that the dependence of output on θ around $\theta = 0$ is quite small, and even for 0.1-db range of output level, about $\pm 8.5°$ can be tolerated. The value of ϕ is obviously not very critical, and it will, in general, be constant. Fig. 3(b) shows separately the two terms making up the fundamental component. The term $\sin(\phi+\theta).J_1(m\theta)$, shown by curves B, represents the output that would be obtained if the modulation were removed from the input to the modulator but not from the injected synchronizing signal. It can be seen that measurement of this curve, in practice, is a

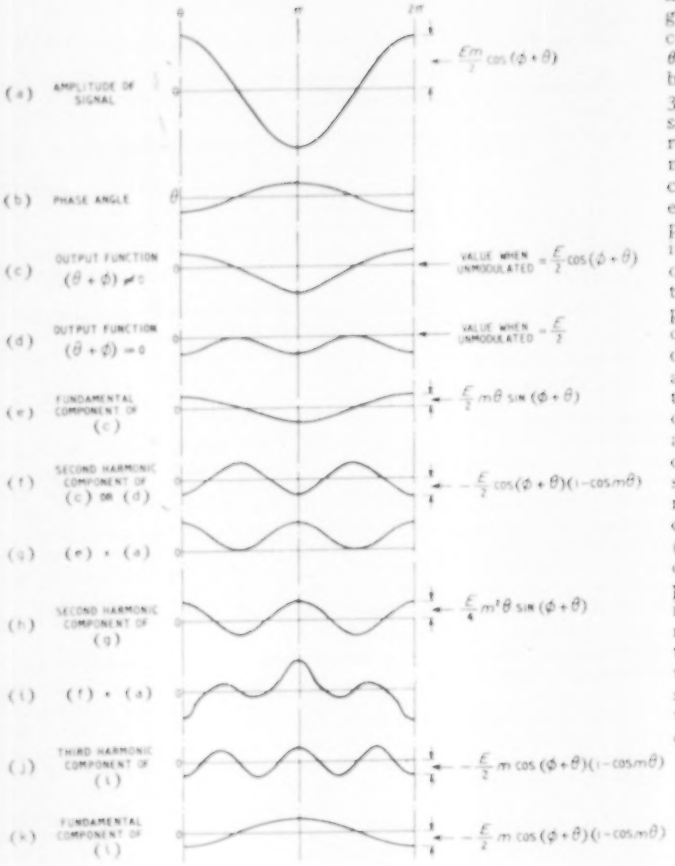

Fig. 2. *The analysis of harmonic production is illustrated by this breakdown of the output into its component waves.*

simple way of measuring ϕ, since the interval between the two zeros is equal to ϕ.

Fig. 4 (a, b, and c) give the 2nd and 3rd harmonic amplitudes. It is evident that for any given maximum tolerable 2nd harmonic, there is an optimum value of ϕ which gives the greatest tolerance on θ. For example, for a harmonic level of about 0.01, $\phi = 0$ gives a range of θ

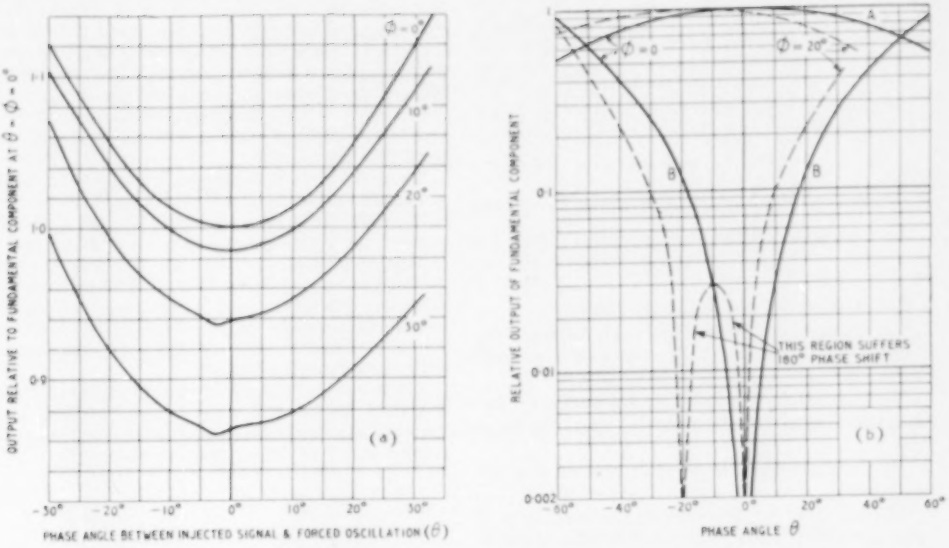

Fig. 3. *Fundamental component of modulation frequency ($m = 0.3$): resultant output (a) and components of the output (b). In the latter, curve A shows the main part of the output and curve B the spurious part.*

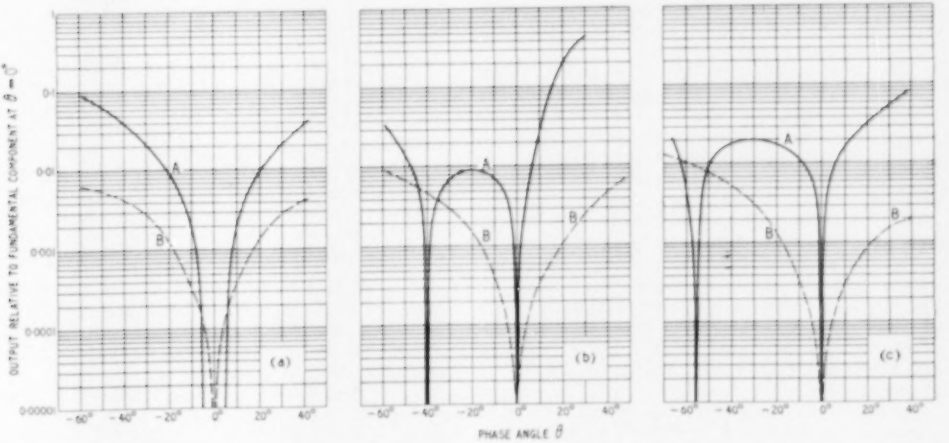

Fig. 4. *Output of harmonics of fundamental modulation frequency for $m = 0.3$: (a) $\phi = 0$, (b) $\phi = 20°$ and (c) $\phi = 30°$. Curves A and B are for second and third harmonics respectively.*

of about 42°, but $\phi = 20°$ gives a range of 54°, and $\phi = 30°$ reduces the range to only 14°.

Fig. 5 shows the d.c. component.

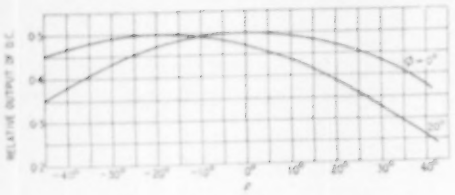

Fig. 5. *Output of d.c. component for* $m = 0.3$.

3. Practical Methods of Achieving Precision

In designing a synchrodyne demodulator for precision work, the following features are, or may be, desirable:

(a) Stability of the oscillator tuning.

(b) Limitation of the phase angle between the locking signal and the local oscillation to a small value, say 10°.

(c) Limitation of stray phase-shifts in the demodulating circuit to a small value, say 10 or 20°.

(d) Constancy of the overall gain of the demodulator.

Feature (a) is of prime importance in equipment with pre-set or fixed tuning. It is also desirable in any equipment, since the need for frequent retuning is always best avoided.

Features (b) and (c) are necessary, as shown in Section 2, if nonlinear distortion is to be avoided.

Feature (d) is relatively unimportant in a radio receiver, but is supremely important in the measuring-equipment application.

To achieve (b), the use of a phase-control circuit involving a valve reactor has already been proposed[9] and used[17]. The valve reactor forms part of the tuned circuit of the oscillator, and it is unfortunate that it may involve considerable instability of tuning, since its reactance is directly proportional to its mutual conductance, which in turn varies considerably with supply voltage and with age. Instability of tuning due to this cause exceeds all other variations. It is now proposed, therefore, to achieve (a) by the use of differential valve reactors in which (in the quiescent condition) equal and opposite reactances are provided by two valves, only one of which is varied by the control voltage.

To achieve (c), it would be possible in a single equipment to insert suitable phase-shifters to correct the phase angles, though to make them effective at more than one frequency may be difficult. In circuits as hitherto published there have always been transformers, and these have phase-shifts which form the bulk of the stray shift. It is found that in practice the phase-shift of a transformer varies considerably from one batch to another (even from one individual to another) and is, in consequence, somewhat unpredictable. If a design is to be suitable for manufacture in quantity, the need for large individual corrections of phase-shift must be avoided, and it is now proposed that all transformers be eliminated by means described later. The circuit is then left with only capacitance-resistance couplings which can be designed to have negligible phase-shift.

To achieve (d) it is necessary to have an adequate amount of feedback on all amplifier stages in the main transmission path. The most difficult part of the circuit to stabilize for gain (or loss) is the modulator, but this can be given a very good short-term stability (say $< \pm 0.05$ db under normal conditions) and a probably adequate long-term stability (say $< \pm 0.25$ db over a 1-month period) by the use of a valve-modulator with modulated feedback[21].

These various aspects of the circuit design are discussed in the following sections. They are dealt with in much more detail, with experimental results, in a Post Office Research Report[26].

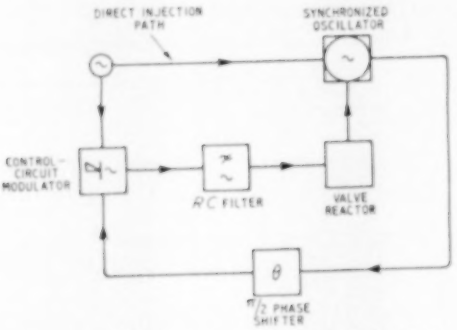

Fig. 6. *Phase-control circuit for synchronized oscillator.*

3.1 *Phase Control by Valve Reactors.*

It is evident from Section 2 that the phase angle between the locking signal and the forced oscillation in the oscillator depends on the amount by which the natural frequency of the oscillator departs from the synchronized frequency. The method of phase control is thus to retune the natural frequency by means of a valve reactor, which is connected as part of the tuning reactances, and whose reactance is controlled by a unidirectional voltage proportional

to the sine of the phase angle. This has been described elsewhere[9], and only the block schematic need be repeated here—see Fig. 6.

The valve reactor provides a reactance between anode and earth when the anode is coupled back

Variations in h.t. voltage can be compensated by feeding a suitable current from the h.t. supply through the cathode resistor. This, if correctly adjusted, causes the grid to become more negative relative to cathode, as the h.t. voltage increases,

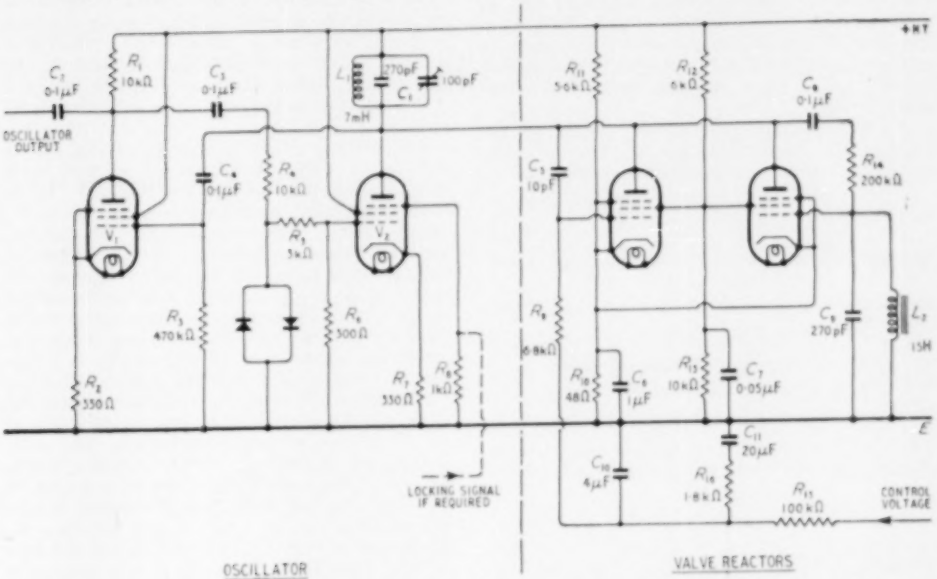

Fig. 7. *Oscillator and differential valve reactor circuits. Component values shown are for an operating frequency of 84 Kc/s.*

to the grid by means of a *RC* circuit giving a suitable phase-shift[22]. When the anode-grid connection is a capacitance, with a resistance from grid to earth, the anode-earth reactance is negative; when the capacitance and resistance are interchanged, the anode-earth reactance is positive. In both cases the reactance magnitude is inversely proportional to the mutual conductance of the valve, and is normally adjusted by varying the bias potential of the control grid. Unfortunately other factors beside this also alter the reactance, namely, h.t. voltage, heater voltage and ageing. Variations of reactance due to such causes may cause the natural frequency in the absence of the control voltage (i.e., before the input signal is connected to the synchrodyne demodulator) to depart greatly from its nominal value, and this may entirely prevent synchronism being attained in a circuit with pre-set tuning although once synchronized by some means it will remain so. The drift of natural frequency may even be sufficient to cause synchronism with unwanted signals. Thus it is generally essential in pre-tuned equipment to reduce these effects.

to an extent such that the mutual conductance is unchanged. It has the additional advantage that a low cathode resistance can be used, thus avoiding a reduction of sensitivity due to negative d.c. feedback.

If two valve reactors are used, one having positive and the other an equal negative reactance, joined in parallel, then any variation of h.t. or heater voltage will affect both valves more or less equally, so that the resultant reactance will not change. The control voltage is applied to one of the valves only, and evidently the overall sensitivity (i.e., change of reactance for a given change of grid voltage) is not affected. There will also be a tendency for both valves to age at the same rate, so that changes of reactance with time are much reduced.

When using a valve reactor with a resistance between anode and grid and capacitance from grid to earth, difficulty usually arises with noise from the h.t. supply, however well it is smoothed, because at very low frequencies the alternating potential of the grid approaches that of the h.t. busbar. It can be appreciated that minute

noise voltages can affect the circuit due to the large frequency changes produced by small grid-voltage changes. This trouble can be avoided by the connection of a choke from grid to earth. The circuit arrangement of the complete stabilized valve-reactor circuit is shown, together with its connection to the oscillator circuit, in Fig. 7. The two *RC* phase-shift circuits from anode to grid are C_3, R_9 and R_{11}, C_9; the h.t. compensation circuit is R_{13}, R_{10}; and the choke referred to above is L_2.

As regards the quantitative design of the circuit, the basic formulae for the effective parallel reactance and resistance are

$$X_0 = \frac{1}{g_m} \cdot \frac{Z_1^2 + Z_2^2}{Z_1 Z_2}$$

and $$R_0 = \frac{r_a(Z_1^2 + Z_2^2)}{Z_1^2 + \mu Z_2^2}$$

where Z_1 = impedance between anode and grid,

Z_2 = impedance between grid and earth,

g_m = mutual conductance of valve,

r_a = a.c. resistance of valve,

μ = amplification factor of valve.

For a positive output reactance, Z_1 is a resistance R_1, and Z_2 is the reactance of C_1, so that

$$X_{01} = +\frac{1 + (\omega C_1 R_1)^2}{g_m \omega C_1 R_1}$$

and $$R_{01} = r_a \frac{1 + (\omega C_1 R_1)^2}{\mu + (\omega C_1 R_1)^2}$$

For a negative output reactance, Z_1 is the reactance of C_2 and Z_2 is a resistance R_2, so that

$$X_{02} = -\frac{1 + (\omega C_2 R_2)^2}{g_m \omega C_2 R_2}$$

and $$R_{02} = r_a \frac{1 + (\omega C_2 R_2)^2}{1 + \mu (\omega C_2 R_2)^2}$$

It is evident that one condition for equality of magnitudes of X_{01} and X_{02} is $C_1 = C_2$ and $R_1 = R_2$, but this will make one or both of the parallel resistance components necessarily very low. Thus the *Q*-factor of the oscillator tuned circuit will be made very small. The more useful condition for the differential valve-reactor circuit is $\omega R_1 C_1 = 1/\omega R_2 C_2$, which gives $X_{01} + X_{02} = 0$, and $R_{01} = R_{02}$ = a high value. This is the basis of choice of the component values in the circuit of Fig. 7.

Control of the reactance by means of a unidirectional voltage applied to the grid depends on the relation between mutual conductance and grid voltage v_g. The relation is not linear, but over a large part of the working range it is approximately so, and in a typical small r.f. pentode (CV 138, V888 or SP 41) with 130 volts h.t., and the circuit values of Fig. 7, a typical value for $\frac{dg_m}{dv_g}$ is about 5 mA V^2.

It is clear that the amount by which the phase angle θ is reduced by this circuit depends on the magnitude of unidirectional control voltage produced by a given phase error. Therefore, if there is no automatic gain control in the signal path feeding the control modulator, the extent of the control will vary with the signal level.

To determine the magnitude of the phase-modulation effect, described in Section 2, is difficult when the phase-control is added. If the latter has a fairly large time-constant in the *RC* filter in the d.c. (control) lead to the valve reactor, then no phase modulation will be introduced through modulation of the valve reactance by the envelope-frequency component in the control circuit*. But in such a case the control circuit cannot follow the variations of phase due to the amplitude modulation of the injected signal, and it would appear that the results of Section 2 still apply. This is so at relatively high levels of injected signal, but at low levels (e.g., > 40 db below the forced oscillation) the phase modulation is reduced. With very low levels, or with the injected signal completely removed, the variation of fundamental output of the demodulator against phase angle becomes the simple cos $(\phi + \theta)$ relationship, and no harmonics of the modulation frequency are generated.

The control circuit is a feedback loop, and as such is liable to hunt or become unstable. It can be shown that the use of an *LC* filter in the d.c. (control) path will cause instability, but if only a single *RC* section is used, hunting will not necessarily occur. The liability to hunt is obviously a function of the loop gain and is, therefore, greatest if a large degree of phase control is aimed at.

It is important to realize that the injected signal (considered as something added to an existing reactance-valve control circuit) has a large stabilizing influence. The ratio of phase angle with injection alone to that with control and injection is large at small injected voltages, but diminishes to small values at large injected voltages[25]. This corresponds to the effect of a smaller loop gain as the injected voltage is increased; hence the increased stability. This is an advantage of using the combination of control and injection as opposed to either alone.

Although by restricting the d.c. filtering to a single *RC* section the control circuit may be

* It should be noted that the time-constant must be large for another reason also—the phase-control circuit must be free from interference by spurious signals, which could otherwise modulate the oscillator phase and give interference in the output of the demodulator.

quite stable, nevertheless, in the absence of an injected signal, it can become unstable. To prevent this, the loop phase-shift/frequency response can be modified by using the *RC* filter circuit as shown in Fig. 8.

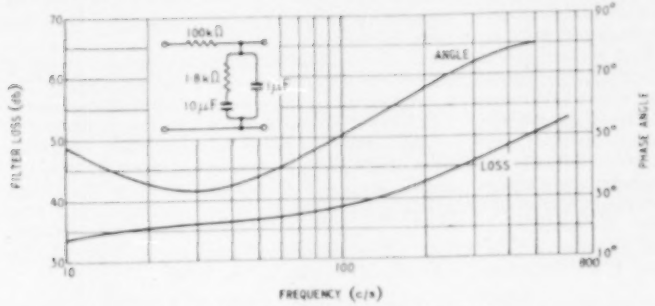

Fig. 8. *Calculated performance of RC filter.*

The use of the combination of control circuit and injected signal has a further advantage over the use of either alone, in that the pull-in frequency range may be increased[25]. As the level of the injected signal is reduced, leaving the control circuit fixed, the pull-in range becomes that of the control circuit alone, which depends on the time-constant, but is generally small. Again, starting from the simple synchrodyne with only the injected signal, the addition of a phase-control circuit causes a large increase in pull-in range, and an even larger increase in pull-out range, (which with plain injection is equal to the pull-in range).

It will have been observed that the addition of a phase-control to the simple synchrodyne which is synchronized by injection, offers certain advantages at the expense of some disadvantages. The further question also arises as to whether the injected signal need be retained when the phase-control is used. The main conclusions are :—

(a) phase-control is necessary for a precision demodulator, where the output of modulation-frequency is required to be constant or the output of harmonics of the modulation frequency is required to be low.

(b) phase-control by reactance valves may cause difficulty with the frequency-stability of the oscillator.

(c) phase-control increases the pull-in frequency range several times, and the pull-out range many times.

(d) the injected signal may be removed provided the phase-control loop has an adequate stability margin.

3.2 Avoidance of Stray Phase-shifts.

Stray phase-shifts in the circuit include those which make up the angle ϕ. It is clear from Section 2 that the restrictions which have to be placed on this angle are far less severe than those on the angle θ. Nevertheless, it is essential to make some limit for either the measuring-equipment or radio-receiver application. In the former case, a large value of ϕ reduces the amplitude of the output signal, but is not otherwise important provided it is constant; and in the latter case, a large value of ϕ causes worse harmonic content over most of the range of θ.

Other stray phase-shifts which may be rather more serious are those in the phase-control loop circuit, since any error in the phase relations at the control modulator will cause the unidirectional control voltage to be zero when the angle θ is different from zero by the amount of the stray shifts.

Factors which cause these stray phase-shifts are :

(a) phase-shifts in coupling circuits,

(b) phase-shifts due to parasitic capacitances,

(c) phase-shift in the oscillator due to harmonic production.

(d) phase-shift due to carrier leak at the control modulator.

The relative magnitudes of (a) and (b) depend on the operating frequency. At frequencies below say 100 kc/s, (a) will predominate, but at frequencies above say 1 Mc/s (b) may predominate. Either or both of these effects will probably be much larger than (c), and all that need be done to deal with (c) is to keep the amplitude of oscillation relatively small so that the harmonic production is small. The method of dealing with (b) is the standard one of keeping anode loads reasonably low, removing avoidable stray capacitances, and using inductance-compensation. It should be possible, provided (a) is dealt with, to operate the circuit with considerable precision and to produce it in quantity, at any rate as a radio receiver, up to 1 or 2 Mc/s at least, and at higher frequencies if only relatively narrow frequency-bands are to be dealt with, so that phase-compensation over a wide frequency-range is unnecessary. The treatment of (d) is to use a well-balanced modulator.

The main cause of phase-shifts under heading (a) is the use of transformers. These occur in

many places in the conventional circuit arrangements; the oscillator will probably be a single-valve type and use one in the tuned circuit; the main modulator may, and the control modulator probably will, involve one or two each. All of these, and particularly that in the oscillator, introduce a considerable phase-shift due to their shunt and leakage inductances and self-capacitances; the leakage inductance is probably the dominant factor, and has the largest effect in the oscillator because the transformer there is likely to be on a dust core of low permeability and with poor coupling between the windings. These phase-shifts are difficult to correct except at single frequencies and, moreover, vary considerably from one individual to another, making production in quantity a very expensive and difficult matter. The solution is to use some special transformerless circuits.

A suitable circuit for a transformerless oscillator using two valves with amplitude-limiting on a pair of rectifiers is shown in Fig. 7. It is desirable to avoid limiting on the valves themselves in order to obtain a suitable oscillation level on the reactance valves.

It should be noted that the phase modulation of the oscillator output, due to an injected synchronizing signal, discussed in Section 2, may, in practice, be considerably modified by various performance features (e.g., dependence of phase-shift on amplitude, and detuning due to harmonics[23]) so that the relation of distortion to phase angle may depart considerably[26] from that calculated for a perfect oscillator.

As far as the radio receiver is concerned, there is no difficulty in avoiding transformers in the main signal modulator, since an ordinary valve frequency-changer operates quite satisfactorily provided it has an adequate local-oscillation voltage and provided no d.c. output is required for tuning-whistle-suppression or for a.g.c. This is not adequate for the measuring set, however, since the valve gives a conversion gain which varies considerably with supply voltages and with age. For this purpose a feedback valve modulator can be used with success, as described elsewhere[21].

For the phase-control modulator, however, a d.c. output is required, and this cannot easily be extracted from a valve modulator because it cannot be distinguished from the anode current. So for this purpose, and for the main modulator when a d.c. output component is required, a valve-fed rectifier modulator should be used, as also described elsewhere[24]. The feedback valve modulator is usually preferable, when no d.c. is required, on account of its conversion gain compared with the conversion loss of the rectifier modulator—the difference usually amounts to about 30 db.

The circuits described above are suitable for a precision transmission-measuring equipment up to about 150 kc/s or for a high-quality radio receiver up to about 2 Mc/s. If either application requires operation at higher frequencies, then two main courses are open:—

(a) Use inductance-compensated coupling circuits to correct phase angles, and (b) use the synchrodyne as an i.f. filter and demodulator following a preliminary frequency-changer.

The former course is suitable where operation over only a relatively narrow band is required, and it may still be possible to keep the circuit suitable for production in quantity, since very precise component values may still be avoidable. But where wideband operation is required, the second course is by far the better.

4. Conclusions

The performance of a synchrodyne demodulator is considerably more difficult to predict than was indicated by the earlier work on the subject and, in particular, the question of phase-modulation of the synchronized oscillator is important. An analysis has been made of the performance to be expected from a synchrodyne demodulator incorporating a perfect oscillator, and an indication has been given of how and why this performance is not generally obtained exactly in practice.

The principles of design of a precision synchrodyne demodulator and some desirable new circuit units have been discussed.

5. Acknowledgments

Acknowledgment of assistance is due to several of the authors' colleagues who have taken part at some stage in the work on which this paper is based. Chief among them is J. Garlick, who did the early development of the phase-control circuit, E. Jeynes and C. D. Thompson who have done much of the experimental work.

REFERENCES

The Homodyne :—

[1] Colebrook, F. M., "Homodyne," *Wireless World*, 1924, Vol. 15, p. 640-8.

[2] Anon., "Homodyne Reception," *Wireless World*, 1942, Vol. 48, p. 87-9.

[3] Urtel, R., German Patent No. 670,585; 1932.

[4] Jarvis, K. W., U.S. Patent No. 2,166,298; 1933.

[5] Starnecki, B. J., Polish Patent No. 28655; 1934.

[6] Wright, G. M., British Patent No. 460,179; 1935.

[7] Curtis, L. F., British Patent No. 516,917; 1939.

The Synchrodyne (as a radio receiver) :—

[8] Tucker, D. G., "The Synchrodyne," *Electronic Engineering*, 1947, Vol. 19, p. 75–6, p. 241–4, p. 276–7, p. 306–7; 1948, Vol. 20, p. 51–4.

[9] Garlick, J., "The Synchrodyne: Control of the Phase Angle between the Output and Injected Signal of the Synchronized Oscillator," *Electronic Engineering*, 1948, Vol. 20, p. 49–50.

(*References continued overleaf.*)

[10] Šádek, V., "Synchrodyne," *Radio Amatér* (Prague), 1948, p. 48.
[11] Smid, J., "Synchrodyne," *ibid*, p. 5.
[12] Apthorpe, F. G., "The Synchrodyne," *Electronic Engineering*, 1947, Vol. 19, p. 258.
[13] Various authors, "The Synchrodyne (Correspondence)," *Electronic Engineering*, 1947, Vol. 19, p. 368–9.
[14] Burnup, J. E., "The Synchrodyne, *Electronic Engineering*, 1948, Vol. 20, p. 65.
[15] "Cathode Ray," "The Synchrodyne," *Wireless World*, 1948, Vol. 54, p. 277–81.

The Synchrolyne (as a selective transmission-measuring equipment) :—

[16] Tucker, E. G., "Highly-Selective Transmission-Measuring Equipment for Communication Circuits," *J. Inst. elect. Engrs*, 1947, Vol. 94, Part III, p. 211–216.
[17] Tucker, D. G., and Gadsick, J., "A Highly-Selective Transmission-Measuring Equipment for 12- and 24-channel Carrier Systems," *P.O. elect. Engrs' J.*, 1948, Vol. 41, p. 166–9.

Other references in text :—

[18] Tucker, D. G., "The Synchronization of Oscillators," *Electronic Engineering*, 1943, Vol. 15, p. 412 and p. 457, and Vol. 16, p. 26 and p. 114f.
[19] Tucker, D. G., "Forced Oscillations in Oscillator Circuits, and the Synchronisation of Oscillators," *J. Instn elect. Engrs*, 1945, Vol. 92, Part III, p. 226.
[20] Tucker, D. G., "Nonlinear Regenerative Circuits," *Wireless Engineer*, 1947, Vol. 24, p. 178.
[21] Tucker, D. G., "Frequency-Changers and Amplifiers with Constant Gain," *Proc. Inst. Radio Engrs.*, 1949, Vol. 37, p. 1324.
[22] Post Office Research Report No. 13012, "The Design of Simple Valve Reactor Circuits for Oscillator Frequency Control," 1948.
[23] Groszkowski, J., "The Interdependence of Frequency Variation and Harmonic Content," *Proc. Inst. Radio Engrs*, 1933, Vol. 21, p. 958.
[24] Tucker, D. G., "Balanced Rectifier Modulators without Transformers," *Electronic Engineering*, 1950, Vol. 22, p. 139.
[25] Post Office Research Report No. 13013, "The Phase Control of Synchronized Oscillators," 1948.
[26] Post Office Research Report No. 13139, "The Synchrodyne as a Precision Demodulator," 1949.

CORRESPONDENCE

Letters to the Editor on technical subjects are always welcome. In publishing such communications the Editors do not necessarily endorse any technical or general statements which they may contain.

Wideband Two-phase Networks

SIR,—In his paper in the March issue, Mr. H. J. Orchard gives an analytical method for designing phase-shift networks. This gives a Tchebycheff approximation to a constant phase difference of 90° over a prescribed frequency band. The mathematical treatment is based on the elliptic sn-, cn- and dn- functions, and the frequency-determining poles of the phase-shift networks are given by the equation

$$\left.\begin{aligned} p_\sigma &= \frac{1}{\sqrt{k'}} \cdot \frac{\mathrm{cn}(u_\sigma, k)}{\mathrm{sn}(u_\sigma, k)} \\ u_\sigma &= \frac{4\sigma + 1}{2n} K\,;\ \sigma = 0,\ 1,\ 2,\ \ldots\ n-1 \end{aligned}\right\} \qquad (22)$$

For the numerical computation Mr. Orchard uses repeated Landen transformations to get the value of $\mathrm{sn}(u_\sigma, k)$ from the trigonometrical sin-function, and $\mathrm{cn}(u_\sigma, k)$ is then calculated from the relation

$$\mathrm{sn}^2(u_\sigma, k) + \mathrm{cn}^2(u_\sigma, k) = 1 \quad \ldots \quad \ldots \quad \ldots \quad (28)$$

The operations involved are straightforward but somewhat tedious, as the author admits. By means of the Jacobian Theta-functions a formula permitting approximation can be derived, with p_σ expressed as a cotangent.

By using the appropriate Theta-functions equation (22) can be written as

$$p_\sigma = \frac{\cos z_\sigma + q^2 \cos 3z_\sigma + q^6 \cos 5z_\sigma + q^{12} \cos 7z_\sigma + \ldots}{\sin z_\sigma - q^2 \sin 3z_\sigma + q^6 \sin 5z_\sigma - q^{12} \sin 7z_\sigma + \ldots} \qquad (1)$$

where

$$z_\sigma = (-1)^\sigma (2\sigma + 1)\frac{\pi}{4n}\,;\ \sigma = 0,\ 1,\ 2\ldots(n-1) \qquad (2)$$

and q can be calculated from equ. (25) or (26), (27), loc. cit.

By putting

$$p_\sigma = \cot B_\sigma \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

and observing that $\cos z + j \sin z = e^{jz}$ we get

$$\frac{\cot B_\sigma + j}{\cot B_\sigma - j} = e^{2jB_\sigma} = \frac{e^{jz_\sigma} + q^2 e^{-3jz_\sigma} + q^6 e^{5jz_\sigma} + q^{12} e^{-7jz_\sigma} + \ldots}{e^{-jz_\sigma} + q^2 e^{3jz_\sigma} + q^6 e^{-5jz_\sigma} + q^{12} e^{7jz_\sigma} + \ldots}$$

$$= e^{2jz_\sigma} \frac{1 + q^2 e^{-4jz_\sigma} + q^6 e^{4jz_\sigma} + q^{12} e^{-8jz_\sigma} + \ldots}{1 + q^2 e^{4jz_\sigma} + q^6 e^{-4jz_\sigma} + q^{12} e^{8jz_\sigma} + \ldots}$$

This can be written as

$$B_\sigma = z_\sigma - z'_\sigma \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

where

$$z'_\sigma = \tan^{-1} \frac{(q^2 - q^6)\sin 4z_\sigma + (q^{12} - q^{20})\sin 8z_\sigma + \ldots}{1 + (q^2 + q^6)\cos 4z_\sigma + (q^{12} + q^{20})\cos 8z_\sigma + \ldots} \qquad (5)$$

In most cases q^6 is a very small quantity, and q^{12} and q^{20} can be discarded altogether.

As Mr. Orchard points out we have $|p_\sigma| = |p_{n-1-\sigma}|^{-1}$ or $|B_\sigma| + |B_{n-1-\sigma}| = \frac{1}{2}\pi$. Thus we need only calculate half the values of p_σ from equations (3), (4), (5), in which case the angle $|4z_\sigma|$ is restricted to the first and second quadrant. We observe that positive values of p_σ correspond to network No. 2, and negative values to network No. 1.

When n is *even* the accuracy of the result can be checked very simply. In this case it is easy to show that the phase-difference between the two sections at the geometrical mid-band frequency $f = \sqrt{f_a f_b}$ can be written as

$$\beta_m = -4 \sum_{\sigma=0}^{\frac{1}{2}n-1} B_\sigma \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

This value of β_m should now differ from 90° by the 'tolerance' ϕ_m if the computations are right.

Often the required frequency range $f_a \leqslant f \leqslant f_b$ for 90-degree phase difference is quite large. The value of q can then be more easily calculated if we start with Theta-functions of modulus $(q')^2$. The relation between q and q' is

$$(\log_{10} q) \cdot (\log_{10} q') = \tfrac{1}{4}(\pi \log_{10} e)^2 = 0.930\ 762 \qquad (7)$$

and between f_a, f_b, q':

$$q' \approx \tfrac{1}{2}\cdot\frac{f_a}{f_b} + \frac{1}{16}\left(\frac{f_a}{f_b}\right)^3 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (8a)$$

$$\text{or } \frac{f_a}{f_b} \approx 4q' - 16(q')^3 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (8b)$$

In the numerical example given by Mr. Orchard $f_a = 200$ c/s, $f_b = 4000$ c/s, $n = 4$. Equation (8a) gives

$$q' = 0.012\ 5078\,;\ \log_{10} q' = -1.902\ 819$$

From equation (7):

$$\log_{10} q = -\frac{0.930\ 762}{1.902\ 819} = 9.510\ 852 - 10\,;\ q = 0.324\ 229$$

Thus $q^2 = 0.105\ 125\,;\ q^6 = 0.001\ 162$. (q^{12} is neglected.)

Equations (2) and (5) give respectively

$$z_0 = 11_0\,15',\ z_1 = -33^0\,45' \text{ and}$$

$$z'_0 = \tan^{-1}\frac{0.073\,513}{1 + 0.075\,156} = 3^\circ\,54'\,41''$$

$$z'_1 = \tan^{-1}\frac{-0.075\,513}{1 - 0.075\,156} = -4^\circ\,32'\,41''$$

This gives

$$B_0 = 7^\circ\,20'\,19''\ ;\ B_1 = -29^\circ\,12'\,19''\ ;$$
$$B_2 = 60^\circ\,47'\,41''\ ;\ B_3 = -82^\circ\,39'\,41''.$$

The poles in network No. 1 are :

$$|\tan B_1| = 0.55900\ ;\ |\tan B_3| = |7.76447$$

in network No. 2 :

$$\tan B_0 = 0.128\,788\ ;\ \tan B_2 = 1.78890$$

These values are in good agreement with those given in the paper, and of more than sufficient accuracy for practical purposes. As a check we may calculate the phase difference at the geometrical mid-band frequency by equation (6) : $\beta_m = 4(29^\circ\,12'\,19'' - 7^\circ\,20'\,19'') = 90^\circ - 2^\circ\,32'$. Equation (25) (loc. cit.) gives $\phi_m = 2^\circ\,31'\,36''$. The angular error in β_m is thus less than 30".

N. O. JOHANNESSON.

Stockholm, Sweden.

An Electrostatic Field Problem

SIR,—I have read with much interest your Editorial in the May issue explaining how the electrostatic force acting upon the surface of a charged sphere concentric within a larger sphere is much greater than the same force pulling inwards upon the inner surface of the encasing sphere.

Might it be permissible to explain the difference in this way? You point out that if the inner charged sphere is in two parts, these will repel one another. To continue this argument : if the inner sphere consisted of a large number of equally-charged particles then each would repel its neighbours, and assuming the sphere to be perfectly regular in shape, it would increase in size without any corresponding inward pull being exerted upon the inner surface of the larger sphere.

This outward force is acting upon the charged sphere whether or not it is in one piece, but does not need to be balanced by a corresponding force from the outer sphere.

I realize that this argument may be fallacious and if so, would appreciate its demolition.

F. D. C. BAKER.

Tunbridge Wells, Kent.

For the sake of simplicity we assumed the inner sphere to be split into two similar parts. It could be assumed to consist of a large number of equally-charged mutually-repellent particles, and the sphere would then increase in size. The total inward pull on the outer sphere is independent of the size of the inner sphere, so long as its total charge remains constant. The total outward pull on the surface of the inner sphere, however, would rapidly decrease, since it is inversely proportional to the square of its radius. As Mr. Baker says, there is no question of the two forces balancing. G. W. O. H.

B.B.C. ENGINEERING DIVISION

R. T. B. Wynn, C.B.E., M.A., M.I.E.E., has been appointed Deputy Chief Engineer and will be responsible under the Chief Engineer, H. Bishop, C.B.E., B.Sc.(Eng.), M.I.E.E., M.I.Mech.E., for the general control and direction of all Engineering Departments.

H. L. Kirke, C.B.E., M.I.E.E., who has been head of the Research Department since 1925 becomes Assistant Chief Engineer and will be responsible for the co-ordination and direction of the technical work of the Research, Planning and Installation, Designs and Equipment Departments. He is succeeded in the Research Department by W. Proctor Wilson, C.B.E., B.Sc., M.I.E.E., and E. C. Drewe, M.I.E.E., becomes Assistant Head of the Department.

NEW BOOKS

Acoustic Measurements

By LEO L. BERANEK, S.D., D.Sc.(Hon.). Pp. 914 + vii. John Wiley & Sons, New York and Chapman & Hall Ltd., 37, Essex St., London, W.C.2. Price 50s.

It can be said without reservation that this volume is of outstanding importance to workers in the acoustical field. Accurate and meaningful measurements in the audio-frequency region are difficult as the majority of measuring elements have dimensions which are comparable, over some portion of the spectrum, with the wavelength of the sound being measured. Free-space conditions are difficult to establish in the laboratory and the combined reaction of sound-source environment and measuring device upon the sound field make it necessary to view all acoustic measurements with suspicion.

Over the past years Dr. Beranek has made many contributions to measuring technique, particularly in obtaining correlation between the various parameters that may be used to define the performance of acoustical absorbents, and he is therefore well qualified to produce a text on the subject.

The material is divided into twenty chapters, of which the first is an historical survey which includes a refreshingly reasonable reference to the work of non-U.S. workers, and a review of acoustical terminology. This is largely based upon the proposed ASA/IRE Standards of 1949.

Chapter 2 has about eighteen pages devoted to a discussion and tabulation of the properties of the gasses which form the usual medium for the propagation of sound. In the remainder of the chapter the various wave equations and the non-linear properties of the medium are discussed.

Chapter 3 is a study of the diffraction effects that result from the introduction of an obstacle in a sound field. A thorough understanding of this is a basic necessity.

The primary technique for the measurement of 'the strength' of a plane sound wave and the calibration of microphones are collected together in Chapter 4 and this includes a most valuable discussion of Reciprocity Technique in calibration. The construction of microphones is more fully dealt with in Chapter 5, which also includes a rather brief description of that devastatingly perfect microphone, the human ear.

Six chapters are then devoted to detailed discussion of the measurement of Frequency, Acoustic Impedance, Microphones, Loudspeakers, Rooms and the properties of Acoustical Materials. The relative merits of using acoustical impedance or absorption coefficient to specify the performance of an absorbent are discussed, and it is noted that the earlier feeling in favour of specifying the acoustic impedance as a unique description of a material is not confirmed.

Other chapters, all excellent, are devoted to that deceptively complex problem, Random Noise, to Indicating and Integrating Instruments and Communication System Tests. The final chapter 'The Sound Level Meter' reviews the ASA and British standard meters and indicates some of the limitations inherent in the instruments.

As a minor point it is believed that some data on the construction and performance of 'free field' rooms would be a valuable addition. This is a subject on which the author is an acknowledged authority.

The book can be unreservedly recommended.

J. M.

Television in Your Home

By W. E. MILLER, M.A. (Cantab.). P. 64 with 30 illustrations. Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1. Price 2s. (Postage 2d.).

ABSTRACTS and REFERENCES

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The abstracts are classified in accordance with the Universal Decimal Classification. They are arranged within broad subject sections in the order of the U.D.C. numbers, except that notices of book reviews are placed at the ends of the sections. U.D.C. numbers marked with a dagger (†) must be regarded as provisional. The abbreviations of the titles of journals are taken from the World List of Scientific Periodicals. Titles that do not appear in this List are abbreviated in a style conforming to it.

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ACOUSTICS AND AUDIO FREQUENCIES

016 : 534 **1838**

References to Contemporary Papers on Acoustics.—A. Taber Jones. (*J. acoust. Soc. Amer.*, March 1950, Vol. 22, No. 2, pp. 297–305.) Continuation of 1047 of May.

534.23 **1839**

Transient Radiation from Sound Sources, and Related Problems.—J. Brilloum. (*Ann. Télécommun.*, April & May 1950, Vol. 5, Nos. 4 & 5, pp. 160–172 & 179–194.) A mathematical introduction outlines the methods of the symbolic calculus used, indicates ways of representing discontinuities and shows how two polynomials, derived from Bessel functions and used in the calculations, can be evaluated. Formulae are derived for the flux and the densities of the radiated and non-radiative energy for the steady state, and examples are calculated for a pulsating and an oscillating sphere. Corresponding general formulae are derived for the waves outside the source under transient conditions. The existence of discontinuities in the wave front and in the end of the wave train is noted. Discussion of sinusoidal radiation shows the importance of the transient waves, for which the ratio of the initial amplitude (of pressure or radial velocity) to that of the steady-state wave increases very rapidly when the radius of the source tends towards zero. Calculations are again made for the pulsating and the oscillating sphere. General formulae are obtained for a rigid sphere subjected to an external force and the two cases of (*a*) unit impulse and (*b*) a sinusoidal force are considered. Various diffraction effects are discussed, with particular reference to the acoustic properties of surfaces with semicylindrical or hemispherical bosses, which act as virtual sources when sound waves reach them. Conclusions stress the importance of the transient waves, which in certain cases are the only ones to be observed.

534.24 **1840**

Phase Distortion of Acoustic Pulses Obliquely Reflected from a Medium of Higher Sound Velocity.—A. B. Arons & D. R. Yennie. (*J. acoust. Soc. Amer.*, March 1950, Vol. 22, No. 2, pp. 231–237.) Since phase shift at reflection depends only on the acoustic parameters of the reflecting interface and the angle of incidence, and is independent of the frequency of the incident wave train, it is to be expected that pulses of arbitrary shape will be subjected to distortion upon reflection. The expected shape of the pressure wave reflected from a semisolid sea bottom at angles exceeding the critical angle of total reflection is derived for the exponentially decaying shock waves produced in underwater explosions, and agrees well with observed pressure/time curves of the first and successively higher-order reflections.

534.24 **1841**

On the Non-Specular Reflection of Sound.—V. Twersky. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, pp. 332–333.) Summary of American Physical Society 1950 Annual Meeting paper N2. The reflection of plane waves by rigid, nonabsorbent surfaces with bosses is analysed.

534.632 : 681.81 **1842**

A Stroboscopic Tuner for Musical Instruments.—A. Douglas. (*Electronic Engng*, May 1950, Vol. 22, No. 267, pp. 178–180.) The apparatus consists of a series of twelve rotating disks, each printed with seven concentric rings of alternate black and white segments, the number of segments increasing successively by a factor of 2 from centre to edge; all twelve are suitably geared together and driven by a common motor. They cover a frequency range of 31–4 000 c/s by semitone intervals. The motor is driven from a tuning fork whose frequency is adjustable over a limited range. The disks are illuminated by neon tubes which are energized, through a microphone and amplifier, by the note emitted by the instrument being tuned, which is thus readily compared with the standard fork frequency.

534.78 **1843**

The Intelligibility of Interrupted Speech.—G. A. Miller & J. C. R. Licklider. (*J. acoust. Soc. Amer.*, March 1950, Vol. 22, No. 2, pp. 167–173.) It is easy to understand noise-free speech provided the interruptions (blanks) occur more than 10 times per second. With interrupting noise, if the ratio of average speech power to average noise power is constant, intelligibility is independent of interrupting frequency if >200/sec. Interrupted masking noise has least effect if interruption frequency is about 15/sec. When interrupted

speech and interrupted noise alternate at frequencies below 10/sec, the noise does not impair intelligibility.

1844

534.78 : 621.395

The Perception of Speech and its Relation to Telephony.—H. Fletcher & R. H. Galt. (*J. acoust. Soc. Amer.*, March 1950, Vol. 22, No. 2, pp. 89–151.) A very comprehensive survey of articulation tests carried out mainly at the Bell Telephone Laboratories and partly at Harvard University. Four sets of data are considered and analysed, covering the years 1919–1925, 1928–1929, 1935–1937 and 1944–1945 (effect of intense noise on intelligibility). "Functions are developed which permit the calculation of articulation index and hence of articulation for communication systems which include a wide range of response/frequency characteristics and of noise conditions, as well as several special types of distortion."

1845

534.833.1

Transmission of Reverberant Sound through Double Walls.—A. London. (*J. acoust. Soc. Amer.*, March 1950, Vol. 22, No. 2, pp. 270–279; *Bur. Stand. J. Res.*, Jan. 1950, Vol. 44, No. 1, pp. 77–88.) The transmission of reverberant sound through a double wall consisting of two identical single walls coupled by an air-space is investigated both theoretically and experimentally. A theory is developed which gives good agreement with experiment.

1846

534.845.1 : 534.846.3

The Determination of Reverberant Sound Absorption Coefficients from Acoustic Impedance Measurements.—A. London. (*J. acoust. Soc. Amer.*, March 1950, Vol. 22, No. 2, pp. 263–269.) A method of predicting the reverberation time of a room from measurements of the absorption coefficient of small samples of the material lining it, when these are used to terminate an acoustic impedance tube. The coefficient for normal incidence measured thereby can be related accurately to the random-incidence case of the room by an empirical statistical treatment.

1847

534.86 : 621.396.712

Developments in Studio Design.—L. L. Beranek. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 470–474.) 1949 I.R.E. National Convention paper. Discussion with particular reference to acoustic properties and studio construction methods used in Broadcasting House, Copenhagen, and Broadcasting House, Oslo.

1848

621.395 : 534.78

A Reference Telephone System for Articulation Tests.—J. Swaffield & R. H. de Wardt. (*P.O. elect. Engrs' J.*, April 1950, Vol. 43, Part 1, pp. 1–7.) Describes equipment supplied by the British Post Office and installed in the C.C.I.F. laboratory, Geneva, for developing and maintaining the proposed new international standards of telephone transmission based on articulation measurements. The equipment consists of a microphone-amplifier-receiver chain having the same transmission characteristics as a 1-m free-air path. Provision is made for the insertion of the telephone circuit under test and for the comparison of the attenuation and noise produced with that of a standard attenuator and noise generator. Apparatus is provided for measuring the speech voltage and the sensitivity or gain of all the elements in the chain, including the microphones and receivers.

1849

621.395.61

Miniature Condenser Microphone.—J. K. Hilliard. (*J. Soc. Mot. Pict. Televis. Engrs*, March 1950, Vol. 54, No. 3, pp. 303–314.) Description of microphone Type 21B, which has a high output level and a uniform frequency response. Its advantages over larger and heavier microphones are enumerated and placing and pickup techniques suitable for motion-picture sound recording are discussed. See also 1319 of June (No 131.)

1850

621.395.61

The "Bantam" Mike — KB–2C.—L. J. Anderson & L. M. Wigington. (*Broadcast News*, March/April 1950, No. 58, pp. 14–17.) An abstract of another account is given in 803 of April.

1851

621.395.623.7

The Acoustical Impedance of Closed Rectangular Loudspeaker Housings.—W. F. Meeker, F. H. Slaymaker & L. L. Merrill. (*J. acoust. Soc. Amer.*, March 1950, Vol. 22, No. 2, pp. 200–210.) Morse's method for calculating pressure distribution in rooms is applied to find the impedance presented to the back of a small loudspeaker by its rigid housing. In a typical case the impedance passes from negative to positive at about 70 c/s, when the maximum linear dimension of the enclosure is $< \lambda/7$. Experiments show that the results depend also on the loudspeaker diaphragm dimensions.

1852

621.395.623.7 : 534.372

Transients and Loudspeaker Damping.—J. Moir. (*Wireless World*, May 1950, Vol. 56, No. 5, pp. 166–170.) Some conflicting theories on optimum amplifier output impedance are investigated experimentally. Little or no improvement of loudspeaker transient reponse is obtained by reducing the amplifier output impedance below 10–20% of the voice-coil impedance. At high frequencies this improvement may be offset because a low output impedance gives a low acoustic output, since the impedance of the voice coil increases with frequency.

1853

621.395.625.2 : 621.395.667

Tone Control with RC Networks in Sound-Recording Technique.—A. Lennartz. (*Funk u. Ton*, April 1950, Vol. 4, No. 4, pp. 169–181.) Taking 1 000 c/s as the reference frequency, and the level at this frequency as reference level, four basic types of correction are defined, viz. bass boost, bass cut, top boost, and top cut; these may be combined as required. Examples of circuits are shown and approximate formulae are derived for component values.

1854

621.395.625.3

Magnetic Recording and its Application in the South African Broadcasting Corporation.—E. J. Middleton. (*Trans. S. Afr. Inst. elect. Engrs*, Feb. 1950, Vol. 41, Part 2, pp. 41–52.) Basic principles are outlined; an account is given of problems encountered in practice, and the main advantages and disadvantages of the system for a broadcasting service are indicated. At present 90% of the S.A.B.C. studio recording is done on disks, but the use of magnetic tape is steadily increasing; for outside work tape is rapidly superseding disk recording.

1855

621.395.625.6

Increased Noise Reduction by Delay Networks.—J. R. Whitney & J. W. Thatcher. (*J. Soc. Mot. Pict. Televis. Engrs*, March 1950, Vol. 54, No. 3, pp. 295–302.) Increased signal/noise ratio in optical sound-film recording is achieved by the use of networks which delay the application of sound currents to the modulator until after the noise-reduction bias current has been partially cancelled. Noise reductions as high as 30 db have been tried successfully and reductions of 15 db have frequently been used in practice.

681.85 1856

Applications of Dynamic Analogies to Cutters and Reproducers for Disks.—G. Bouchier. (*Radio franç.*, April 1950, No. 4, pp. 9–10.) Problems relating to disk recorders and reproducers are treated by analogy with the corresponding problems in electrical circuitry, L taking the place of moment of inertia, C of compliance, and R of mechanical resistance; the angular velocity of the stylus is then represented by current. The response at different frequencies is calculated for a magnetic lateral cutter and pickup with different degrees of mechanical damping; results are shown in tables and graphs.

534.6 1857

Acoustic Measurements. [Book Review]—L. L. Beranek. Publishers: J. Wiley, New York, 1949, 896 pp., $7.00. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, p. 578; *Rev. sci. Instrum.*, April 1950, Vol. 21, No. 4, p. 387.) The author "has made a valuable addition to our technical literature and his reference volume should have a long life in the libraries of all engineers whose work touches on sound measurements."

AERIALS AND TRANSMISSION LINES

621.3.09 1858

Propagation of Electromagnetic Disturbances along a Thin Wire in a Horizontally Stratified Medium.—B. L. Coleman. (*Phil. Mag.*, March 1950, Vol. 41, No. 314, pp. 276–288.) "For a thin wire buried at finite depth in a semi-infinite homogeneous medium and subject to a disturbance at a given frequency, there exists an exponential attenuation of the current in the wire with a propagation constant equal to that of the medium. This result is extended to a medium with a number of layers, and to a wire lying in an interface."

621.3.09 : 621.385.029.63 : 64 1859

Experimental Study of the Propagation along a Delay Line in the Form of a Helix.—M. Jessel & R. Wallauschek. (*Ann. Télécommun.*, Aug./Sept. 1948, Vol. 3, Nos. 8/9, pp. 291–299.) An investigation of the effect of variation of the following factors: (*a*) the material of the conductor (Cu, Fe, steel, and chrome alloys); (*b*) the diameter of the wire (0.33 to 0.7 mm); (*c*) the pitch of the helix; (*d*) the wavelength; (*e*) the diameter of the helix. Other factors affecting attenuation are considered. The method of measurement is described; experimental results are shown graphically.

621.392.26† : 621.3.09 1860

Electromagnetic Waves in Rectangular Waveguides.—K. S. Knol. (*Tijdschr. ned. Radiogenoot.*, March 1950, Vol. 15, No. 2, pp. 53–74. In Dutch, with English summary.) A resumé of waveguide theory is given. Brillouin's method for rectangular waveguides is treated in some detail and the solution of Maxwell's equations for the interior of a waveguide is found by considering the superposition on the incident wave of the three reflected waves resulting from the rectangular construction. An attenuator is described which uses a coaxial line of adjustable length within a waveguide excited at a wavelength much greater than the critical value.

621.392.26† : 621.3.09 1861

A Model for Studying Electromagnetic Waves in Rectangular Wave Guides.—K. S. Knol & G. Diemer. (*Philips tech. Rev.*, Nov. 1949, Vol. 11, No. 5, pp. 156–163.) A rubber-membrane model is described.

621.392.26† : 621.3.09 1862

Mode Conversion Losses in Transmission of Circular Electric Waves through Slightly Non-Cylindrical Guides.—S. P. Morgan, Jr. (*J. appl. Phys.*, April 1950, Vol. 21, No. 4, pp. 329–338.) A general expression is derived for the effective attenuation owing to mode conversions in a deformed section of waveguide. In the special case of elliptical deformation the theory gives results in agreement with experiment. The effects of random distortions in a long waveguide are analysed and typical examples of the magnitude of the loss are given.

621.396.67 1863

Antifading Broadcast Antenna.—H. Brueckmann. (*Electronics*, May 1950, Vol. 23, No. 5, pp. 82–85.) In the case of base-fed towers the progressive wave along the aerial gives rise to high-angle radiation which results in fading due to interference between ground- and sky-waves. The aerial here described is composed of insulated sections and fed at the insulator, some way up, so that the effects of the progressive waves in the two sections cancel one another, giving an enlarged service area. The performance of such an aerial at Radio Frankfurt, operating on 1195 kc/s, was measured and some results are tabulated.

621.396.67 : 621.317.79 1864

Ripple Tank for Phase-Front Visualization.—(*See* 1979.)

621.396.67 : 621.397.5 1865

High-Gain and Directional Antennas for Television Broadcasting.—L. J. Wolf. (*Broadcast News*, March/April 1950, No. 58, pp. 46–53.) Illustrated description of the R.C.A. Supergain aerial, with diagrams showing typical radiation patterns and installations with different combinations of the radiating elements.

621.396.67.012 1866

Radiation Characteristics of a Turnstile Antenna in a Cylindrical Shield.—D. S. Saxon, A. Baños, Jr, & L. L. Bailin. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 327.) Summary of American Physical Society 1950 Annual Meeting paper HA5. The aerial investigated consists of crossed wires excited in quadrature. The axis of the shield is perpendicular to the plane of the aerial; it is open at one end, and its diameter is a fraction of the driving wavelength. Excitation of an infinitely long circular waveguide is considered, and conditions under which only the dominant (TE_{11}) mode is important are determined; the radiation problem is then treated as one in which a semi-infinite circular guide, excited by a TE_{11} mode, radiates into free space. Using a solution obtained by Levine & Schwinger (not yet published) values of reflection coefficient and gain function have been computed. Results are compared with those found experimentally and by the Kirchhoff method.

621.396.67.012 1867

On the Radiation Patterns of Dielectric Rods of Circular Cross-Section.—C. W. Horton, F. C. Karal & C. M. McKinney. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, pp. 327–328.) Summary of American Physical Society 1950 Annual Meeting paper HA6. Theoretical patterns are calculated for different diameters, lengths and modes of excitation, the fields in the radiators being assumed the same as in an infinitely long dielectric guide. Correction is made for finite rod length by substituting an equivalent rod of smaller diameter with dielectric constant such that the wavelength of the guided wave is unchanged. In a particular case studied good agreement was found between theory and experiment.

621.396.677 1868

Theory and Application of Transit-Time Compensators in Transmitters and Receivers of Beamed Electromagnetic Waves.—H. Stenzel. (*Fernmeldetech. Z.*, March & April 1950, Vol. 3, Nos. 3 & 4, pp. 94–100 & 125–132.) By analogy with the principle of compensation as applied to a ship's sound-detection apparatus, general formulae are derived for the characteristics of compensated e.m. radiating systems. The use made of transit-time networks in the strip and the cylinder compensator is described. Straight-line grouping and circular grouping of radiators are considered. The grouping characteristic of arbitrary arrangements of radiators is investigated experimentally, using a c.r. tube as indicator. With quarter-circle grouping of the radiators a direct indication of signal bearing can be obtained on a c.r.o. by application of the sum-and-difference method of acoustics.

621.396.677.029.6 1869

Directional Antenna Systems at Microwave Frequencies.—C. A. Rosencrans. (*Broadcast News*, March/April 1950, No. 58, pp. 28–35.) Discussion of the practical solution of various problems associated with the design and installation of microwave radio links.

CIRCUITS AND CIRCUIT ELEMENTS

621.3.016.35 : 621.392.5 1870

The Nyquist Criterion of Stability.—J. C. West. (*Electronic Engng*, May 1950, Vol. 22, No. 267, pp. 169–172.) A semi-graphical demonstration for the case of feedback systems.

621.314.2 : 621.3.017 1871

Current Density and Permissible Heating in Small Transformers.—U. Finkbein. (*Funk u. Ton*, April 1950, Vol. 4, No. 4, pp. 182–192.) The loading of a transformer is limited only by the permissible heating, which depends on the current density. Since the same laws hold for the steady flow of heat as for the steady flow of electricity, the calculations for the former case may be made by constructing equivalent circuit diagrams in which the values of the equivalent resistances are found from consideration of the conduction, convection and radiation processes. For heating due to copper and iron losses the equivalent circuit is a quadripole. For low-power transformers the current density may be allowed to reach 6 A/mm², but for powers of about 2 kVA it should not exceed about 1 A/mm².

621.314.2.083 : 621.317.612 1872

On the Measurement of the No-Load Losses of Small 50-c/s Transformers.—Medina. (*See* 1967.)

621.314.3† 1873

Analysis of Transients and Feedback in Magnetic Amplifiers.—W. C. Johnson & F. W. Latson. (*Elect. Engng, N.Y.*, April 1950, Vol. 69, No. 4, pp. 353–359.) A.I.E.E. 1950 Winter General Meeting paper. The steady-state characteristics of a saturable reactor can be used to determine the effect of feedback on the properties of the reactor. The equivalent control circuits for saturable reactors are discussed and formulae are derived for computing the performance of certain types of magnetic amplifier.

621.318.4.011.3 1874

Inductance of Toroidal Coils.—R. Cazenave. (*Rev. gén. Elect.*, April 1950, Vol. 59, No. 4, pp. 169–174.) The inductance is greater than the approximate value calculated from elementary theory. For maximum inductance the greatest dimension of the winding cross-section should be perpendicular to the axis of the toroid. Suitable formulae are given for coils of various cross-sections commonly used.

621.318.42 + 621.314.2 1875

Inductors and Transformers for High Frequencies.—P. M. Prache. (*Câbles & Transmission, Paris*, April 1950, Vol. 4, No. 2, pp. 89–125.) The dynamic effect on the core of the e.m.f. generated by the variation of the magnetic field is not negligible at relatively high frequencies. This magnetodynamic propagation is analysed for metal-strip, wire, and dust cores. Its effect is to concentrate the magnetic flux towards the outer surface of the core; this 'magnetic skin effect' causes a reduction of the apparent permeability and the Q of an inductor. The variation of the reduction coefficient with frequency is calculated for the different types of core considered. The effect on the windings is dealt with similarly, calculations being made of the changes of inductance, distributed capacitance, resistance and loss caused by leakage of current between turns and between winding and core. The various parameters and their variation with frequency are determined in the two cases. Numerous experimental results confirm the theory.

621.392 1876

Method of Determining the 'Trees' ["arbres"] of a Network.—J. Lantieri. (*Ann. Télécommun.*, May 1950, Vol. 5, No. 5, pp. 204–208.) The term 'tree' is applied to an open-circuit combination of the branches of a network including all the junctions. Any network has a representative geometrical configuration defined by a matrix. The solution of certain network problems can be simplified by the use of matrix calculus, which is here applied to determine (*a*) the nature and number of the 'trees' in the Carey-Foster bridge, (*b*) the admittance of a passive 2-pole network with no mutual impedance, (*c*) the voltage across the second diagonal of a Wheatstone bridge.

621.392 : 681.142 1877

Diode Coincidence and Mixing Circuits in Digital Computers.—Tung Chang Chen. (*See* 1958.)

621.392.5/.6 1878

Construction of Quadripoles and Multipoles with given Frequency Characteristics.—V. A. Taft. (*Bull. Acad. Sci. U.R.S.S. tech. Sci.*, Feb. 1950, No. 2, pp. 216–232. In Russian.) Methods are indicated for constructing passive quadripoles and multipoles (for certain particular cases) with given frequency characteristics, and the necessary and sufficient conditions for their construction to be possible are established. The problem of the construction of circuits from passive elements R, L, C and M, which would be equivalent to a given system of ordinary differential equations is also discussed. This question is of practical importance in the design of electrical calculating machines. The methods developed can be used for constructing networks with given properties if the impedance (or admittance) function satisfies the conditions of realization and is expressed in the form of rational fractions. Otherwise the given relations must be first approximated by rational fractions.

621.392.5 1879

Complementary Note on the Synthesis of Passive, Resistanceless Four-Poles.—B. D. H. Tellegen. (*Philips Res. Rep.*, Oct. 1949, Vol. 4, No. 5, pp. 366–369.) Continuation of 2745 of 1949. By removing a pole at a finite value of the frequency a passive resistanceless quadripole of order n can be split up into two quadripoles, one of the second order and one of order $(n-2)$.

621.392.5 1880

Reciprocal Aspects of Transient and Steady-State Concepts.—W. J. Kessler. (*Elect. Engng, N.Y.*, April 1950, Vol. 69, No. 4, pp. 319–321.) "The transient response of a network can be defined in steady-state

terms, and the steady-state behavior can be described in transient terms. The steady-state behavior is usually defined in terms of amplitude and frequency while the transient behavior is defined in terms of amplitude and time. Therefore, the transient and steady-state responses are regarded as nothing more than alternative viewpoints of network behavior when it is expressed in the time domain or the frequency domain respectively."

621.392.52 **1881**

Phase-Shift Band-Pass Filters.—D. H. Pickens & J. N. Van Scoyoc. (*Electronics*, May 1950, Vol. 23, No. 5, pp. 96–99.) The phase shift of a bridged-T network changes by 180° as the frequency passes through its null value. By subtracting the output of such a network from that of a similar one with a different null frequency, frequencies between the null frequencies can be transmitted and those outside this band cancelled. Readily available components can be used, even at low audio frequencies. Circuits for the differential combination of the two outputs are described.

621.392.6.029.63 + 621.317.336/.34 **1882**

Theory and Technique of Multipole Networks at Ultra-High Frequencies.—G. Goudet & H. Jassin. (*Onde Elect.*, April & May 1950, Vol. 30, Nos. 277 & 278, pp. 178–194 & 223–226.) The theory is reduced to a general form applicable to u.h.f. and lower frequencies by consideration of normalized impedance and electric and magnetic intensities and by application of matrix calculus. The multipole network may be terminated by any form of waveguide or transmission line. The second part of the paper describes a method of measurement at about 3 kMc/s of the impedance, attenuation and wave-propagation velocity of coaxial cables. A method is also given for measuring the transmission and reflection coefficients of coaxial plug connectors. Typical results are given.

621.396.6 + 621.317.7 + 621.38.001.8 **1883**

Physical Society's Exhibition.—(*Wireless Engr*, May 1950, Vol. 27, No. 320, pp. 158–163; *Wireless World*, May 1950, Vol. 56, No. 5, pp. 171–175; *Instrum. Practice*, March 1950, Vol. 4, No. 5, pp. 237–249; *Elect. Times*, 30th March 1950, Vol. 117, No. 3047, pp. 503–510; *Engineer, Lond.*, 31st March, 7th & 14th April 1950, Vol. 189, Nos. 4914–4916, pp. 397–398, 411–415 & 444–448; *Engineering, Lond.*, 7th & 14th April 1950, Vol. 169, Nos. 4393 & 4394, pp. 377–380 & 401–404.) Electronic equipment for research and measurement shown at the exhibition held in London from 31st March to 5th April 1950.

621.396.615 **1884**

Frequency and Amplitude Stability of the Cathode-Coupled Oscillator.—P. G. Sulzer. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 540–542.) The effects of supply-voltage variations are calculated, and the theoretical results are confirmed by experiment. Cathode-coupled oscillators can have excellent frequency stability.

621.396.615.14 + 621.396.645 **1885**

Annular Circuits for High-Power, Multiple-Tube, Radio-Frequency Generators at Very-High Frequencies and Ultra-High Frequencies.—D. H. Preist. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 515–520.) 1949 I.R.E. National Convention paper. A resonator is used which consists of a thick cylinder inserted between an axial and an outer conductor which are electrically connected. The inner and outer conductors are excited in antiphase to the thick cylinder. This construction makes possible multi-valve power amplifiers having the same upper frequency limit and efficiency as a single valve, and also permits the use of a coaxial output line without coupling probes or loops.

621.396.615.17 **1886**

The Multivibrator and its Recent Developments.—J. Moline. (*Radio franç.*, April & May 1950, Nos. 4 & 5, pp. 17–21 & 16–20.) Discussion of variants of the basic circuit, including flip-flop and scale-of-two circuits and a generator of square waves.

621.396.615.17.029.4 **1887**

Rectangular-Wave Generator for Biological Studies.—J. W. Moore. (*Electronics*, May 1950, Vol. 23, No. 5, pp. 122–190.) Description of a circuit comprising multivibrator, univibrator, clipper and power amplifier, which has been used for over 2 years to produce negative pulses at repetition rates of $\frac{1}{2}$ to 400 c/s with pulse durations of 20 μs to 1.5 s.

621.396.645 : 539.16.08 **1888**

Linear Amplifiers.—M. A. Schultz. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 475–485.) The requirements of an amplifier for use with an ionization chamber in nuclear research are that it shall have an adjustable rise-time characteristic (0.1 to 20 μs) to handle a wide range of pulse widths and shall have a linear response to random pulses within the amplitude range 10 μV – 50 mV. The amplifier must also be capable of handling small pulses in the presence of large pulses and vice versa. Noise, bandwidth and overload considerations are discussed and practical circuits described.

621.396.645.35 **1889**

The Construction and Operation of a Highly Sensitive Direct-Voltage Amplifier.—H. Boucke & H. Lennartz. (*Funk u. Ton*, April 1950, Vol. 4, No. 4, pp. 161–168.) Discussion of the modifications to Kerkhof's design (1387 of 1943) necessary to overcome such difficulties as insufficient amplification, changing of bridge balance during long warming-up period, residual voltage at the output. Measures taken include increasing the selectivity of the h.f. circuits, introducing hum filters, and careful screening.

621.397.645 **1890**

Wide-Band Chain Amplifier for TV.—Tyminski. (*See* 2018.)

621.392 **1891**

Communication Circuit Fundamentals. [Book Review]—C. E. Smith. Publishers: McGraw-Hill Book Co., New York, 401 pp., $5.00. (*Radio & Televis. News, Radio-Electronic Engng Supplement*, April 1950, Vol. 14, No. 4, p. 28.) "The second of four books designed for a complete course in radio and communication engineering." The first book, Applied Mathematics for Radio and Communication Engineers, was noted in 112 of 1946.

621.392 **1892**

Matrix Analysis of Electric Networks. [Book Review]—P. Le Corbeiller. Publishers: Harvard University Press and J. Wiley, New York, 1950, 108 pp., $3.00. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, p. 576; *Rev. sci. Instrum.*, April 1950, Vol. 21, No. 4, p. 381.) "The first of a series of monographs on applied science to be published by Harvard University in order to make the results of University research available to a wider audience than would be reached by individual professional journals . . . Its purpose is to offer a simplified and gradual approach to Kron's method of analysis of stationary electric networks . . . . It can be highly recommended to all radio engineers who want to keep in touch with modern advances in network theory."

GENERAL PHYSICS

001 + 53 1893

A Sampling of 1949 Books.—(*J. appl. Phys.*, April 1950, Vol. 21, No. 4, pp. 352–368.) Brief individual comments are given on a selected list of new books noted during late 1948 and 1949, mostly in the field of mathematics, physics, radiocommunications and electronics.

534.24 + 535.312] : 519.3 1894

A Variational Principle for the Computation of Reflection Coefficients.—G. Toraldo di Francia. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 298.) Previously used for computing phase shifts and transmission cross-sections, this principle is here applied to the calculation of the reflection coefficient of a potential barrier. See also 1052 of May (Levine).

535.13 1895

General Operator Field Equations Derived from a Variation Principle. Construction of "Divergence-Less" Four-Vector Operator.—C. Gregory. (*Phys. Rev.*, 15th May 1950, Vol. 78, No. 4, p. 479.)

535.222 1896

A Measurement of the Velocity of Light.—R. A. Houstoun. (*Nature, Lond.*, 10th Dec. 1949, Vol. 164, No. 4180, p. 1004.) A quartz crystal is substituted for the toothed wheel used in Fizeau's method of measurement and in an alternating electric field acts as an intermittent diffraction grating. The light in the first-order spectrum is interrupted 200 times as rapidly as by Fizeau's toothed wheel. Light, after passing through the quartz, travelled a distance of about 30 m and was then reflected back through the quartz to the eye of the observer. For a particular path length the intensity has a minimum value. The velocity deduced, when reduced to vacuum, is 299 775 km/s. Measurement accuracy is about the same as that of other recent determinations, but could be increased 10 times with a tenfold increase of range. A full account of the work will be published elsewhere. See also 42 of 1939, 3244 of 1941 and 2010 below.

535.42 + 534.26 1897

On the Theory of Diffraction by an Aperture in an Infinite Plane Screen: Part 2.—H. Levine & J. Schwinger. (*Phys. Rev.*, 1st May 1949, Vol. 75, No. 9, pp. 1423–1432.) In part 1 (83 of January) the problem of diffraction of a scalar plane wave was dealt with by a variational principle in which the aperture was regarded as coupling the two half-spaces on opposite sides of the screen. In part 2 a different variational principle is developed by considering the screen as an obstacle to the propagation of the wave. Calculated values of transmission coefficient are shown graphically against the ratio aperture-radius/λ for the particular case of circular aperture and normal wave incidence. Results are compared with exact values calculated by Bouwkamp; the degree of approximation is good.

535.42 1898

Diffraction by a Cylindrical Obstacle.—C. H. Papas. (*J. appl. Phys.*, April 1950, Vol. 21, No. 4, pp. 318–325.) The diffraction of a plane wave by an infinitely long perfectly conducting cylinder whose axis is parallel to the electric vector is treated by the variational method of Levine and Schwinger (83 of January and 1897 above) which avoids the difficulties of earlier methods. The scattering cross-sections for wavelengths large and small with respect to the radius a of the cylinder are computed and shown graphically. The cross-section approaches the value $4a$ as ka $(=2\pi/\lambda)$ approaches infinity.

537.226.001.11 1899

Properties of Slow Electrons in Polar Materials.—H. Fröhlich, H. Pelzer & S. Zienau. (*Phil. Mag.*, March 1950, Vol. 41, No. 314, pp. 221–242.) Energy problems in the interaction between an electron and a continuous dielectric medium are investigated theoretically by a variational method.

537.311.5 : 621.3.015.3 1900

Density Distribution of Transient Currents in Conductors.—L. M. Vallese. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, p. 563.) Analysis of the distribution of an exponential-decay current and of a pulse current.

537.525 1901

The Collection of Positive Ions by a Probe in an Electrical Discharge.—R. L. F. Boyd. (*Proc. roy. Soc. A*, 20th April 1950, Vol. 201, No. 1066, pp. 329–347.) The Langmuir probe method for determining electron temperature gives anomalous results when applied to positive ions. The theoretical aspects of the collection of positive ions are discussed; the conclusions were tested in experiments using a special probe in an argon discharge. The probe consisted of a plane Pt foil screened by a fine wire grid whose potential could be adjusted separately; this device permitted the probe current to be separated into its electron and ion components.

537.581 1902

Convenient Methods for Thermionic Emission Calculations.—H. F. Ivey & C. L. Shackelford. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 356.) Summary of American Physical Society 1950 Annual Meeting paper EP24. Four simple methods are presented by which any one of the quantities Φ, A, T, J in Richardson's equation can be found if the others are known. In the first method, the equation is reduced to a simple form involving T only in the exponential term. Two other methods are graphical, and the fourth uses an abac. The accuracy is discussed in each case.

538.082.74 : 538.653.11 1903

On the Propagation of Large Barkhausen Discontinuities in Ni-Fe Alloys.—L. J. Dijkstra & J. L. Snoek. (*Philips Res. Rep.*, Oct. 1949, Vol. 4, No. 5, pp. 334–356.) "The propagation of the Bloch boundary between two macro-domains under the influence of an external magnetic field H is investigated for Ni-Fe wires of the composition 60-40 and 50-50 subjected to a tensile stress. The quantities involved are the axial rate of propagation v and the effective length λ of the discontinuity. . . . A review is given of the various factors determining the shape of the boundary and the rate of propagation v. The experimental results lead to the concept that the movement of the Bloch boundary is impeded by two causes of different origin, one being the eddy-current effect, the other probably a spin-relaxation effect."

538.569.4 + [621.396.11 : 535.312 1904

Absorption and Reflexion of U.H.F. Waves (300–500 Mc/s) by Sea Water.—S. K. Chatterjee & B. V. Sreekantan. (*Indian J. Phys.*, June 1949, Vol. 23, No. 6, pp. 273–279.) A parallel beam was passed through a solution simulating sea water. Intensity measurements indicated maximum absorption at 380 Mc/s and very little variation of the reflection coefficient over the frequency range investigated. Dielectric constant and conductivity increased with frequency. See also 1921 of 1949.

538.569.4 1905

A Square-Wave Modulation Method for Microwave Spectra.—T. R. Hartz & A. van der Ziel. (*Phys. Rev.*, 15th May 1950, Vol. 78, No. 4, p. 473.) The double-modulation method used by Gordy & Kessler (3125 of 1949) and Watts & Williams (1017 of 1948) is modified, with consequent improvement of sensitivity, by substituting a 50-kc/s square-wave voltage of 10 V or more for the sinusoidal r.f. modulation applied in conjunction with l.f. sawtooth voltage to the klystron reflector.

539.234 : 537.581 1906

The Use of Radioactive Sr in some Thermionic Experiments on Thin Films.—H. W. Allison & G. E. Moore. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, pp. 354–355.) Summary of American Physical Society 1950 Annual Meeting paper EP15. Electron emission measurements made by a tracer method at low temperatures on films of Sr and SrO 1–10 molecules thick evaporated on to tungsten ribbons indicate thermionic activity comparable with that of BaO-SrO cathodes. The technique is described and quantitative results given.

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.53 : 621.396.9 1907

On Meteor Speed Measurements by the Radio Doppler Method at Low Frequencies.—D. D. Cherry & C. S. Shyman. (*Phys. Rev.*, 1st May 1949, Vol. 75, No. 9, pp. 1441–1442.) Measurements were made during the Geminid shower of 11th Dec. 1948 at 30.66 Mc/s and 12.8625 Mc/s simultaneously. Results are compared; the frequency used does not appear to affect the value of velocity found.

523.72 : 621.396.822 1908

Investigations of Radio-Frequency Radiations from the Sun during the Total Solar Eclipse of 20th May, 1947.—S. E. Khaykin & B. M. Chikhachev. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, Jan./Feb. 1948, Vol. 12, No. 1, pp. 38–43. In Russian.) See 1135 of May.

523.72 : 621.396.822 1909

The Growth of Circularly Polarized Waves in the Sun's Atmosphere and their Escape into Space.—V. A. Bailey. (*Phys. Rev.*, 15th May 1950, Vol. 78, No. 4, pp. 428–443.) The theory of plane waves in an ionized medium pervaded by static electric and magnetic fields (2785 of 1949) predicts wave amplification and consequent noise in certain frequency bands. For given frequency and electron drift velocity two independent trios of waves are produced, having circular and mutually opposed polarization. The conditions are established under which a growing flux of energy carried by the waves can pass normally through the boundary between two ionized media, and the theory is applied to show that powerful waves can arise from growth of random transverse perturbations above sunspots and that these waves can escape into space; observations of solar noise are correlated with these phenomena. The ultimate intensity attainable by such a perturbation is discussed.

523.745 : 550.385 1910

Geomagnetic Storms and Solar Activity 1949.—H. W. Newton. (*Observatory*, April 1950, Vol. 70, No. 855, pp. 84–86.) Geomagnetic activity was on the whole higher than during 1948, sunspot frequency about the same. Data are tabulated for magnetic storms recorded at Abinger.

523.75 1911

The Solar Flare of 1949 November 19.—M. A. Ellison & M. Conway. (*Observatory*, April 1950, Vol. 70, No. 855, pp. 77–80.) A short account of the development and spectrum of this flare, which was associated with the largest changes of cosmic-ray and neutron intensity ever recorded. The sky-wave signal disappeared abruptly on the three Decca frequencies (70, 113 and 127 kc/s) and did not reappear until about 5 hours later. There was a simultaneous enhancement of atmospherics recorded on a frequency of 22 kc/s and also a fade-out of signals in the frequency range 5–20 Mc/s.

551.51 1912

Physics and the Atmosphere.—G. M. B. Dobson. (*Proc. phys. Soc.*, 1st April 1950, Vol. 63, No. 364B, pp. 252–266.) Text of the 5th Charles Chree Address, given on 4th Nov. 1949. Includes an account of investigations of atmospheric ozone.

551.510.5 : 546.21 1913

The Distribution of Atomic and Molecular Oxygen in the Upper Atmosphere.—H. E. Moses & Ta-You Wu. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 333.) Summary of American Physical Society 1950 Annual Meeting paper N7. From the usual steady-state gas conditions, together with an appropriate form of the barometric equation, theoretical calculations are made of the number density of O_2 and O and of the temperature, all as functions of height, the temperature and its gradient being known at one height. According to these calculations, dissociation of O_2 is not complete till about 200 km, and the maximum number density of O, occurring at about 100 km, is about 10^{11}/cm^3, which is considerably less than estimated by previous workers.

551.510.535 1914

On Investigations of the F_2 Layer of the Ionosphere during the Total Solar Eclipse of 20th May, 1947.—Ya. L. Al'pert. (*Bull. Acad. Sci. U.R.S.S., sér. phys.*, Jan./Feb. 1948, Vol. 12, No. 1, pp. 44–48. In Russian.) See 1147 of May.

551.510.535 1915

On the Frequency of Occurrence and the Structure of the E_2 Layer of the Ionosphere.—W. Becker & W. Dieminger. (*Naturwissenschaften*, Feb. 1950, Vol. 37, No. 4, pp. 90–91.) The reflection heights of the ordinary and extraordinary rays for the E_1, E_2 and E_3 layers are more clearly identified by the use of high-power equipment (see 892 of April). Two typical records obtained at the Max Planck Institute for Ionosphere Research are reproduced. Mean values of limiting frequencies for and heights of the E_2 layer at half-hourly intervals for August 1949 are tabulated and discussed. The slight thickness of the E_2 layer makes it probable that its existence is due to neutral corpuscles radiated by the sun. The sporadic-E layer should be distinguished according to its height and uniformity and the time of day.

551.510.535 : 621.396.11 1916

Radio Wave Propagation in a Curved Ionosphere.—Kelso. (*See* 2013.)

LOCATION AND AIDS TO NAVIGATION

621.396.9 : 523.53 1917

On Meteor Speed Measurements by the Radio Doppler Method at Low Frequencies.—Cherry & Shyman. (*See* 1907.)

621.396.933 1918

Traffic Handling Capacity of 100-Channel Distance-Measuring-Equipment (DME) Standardized by R.T.C.A. SC-40 and I.C.A.O.—C. J. Hirsch. (*Proc. Radio Cl. Amer.*, 1950, Vol. 27, No. 2, pp. 3–25.) Normal operation of the equipment is discussed. Decreased efficiency may result from (*a*) transponder dead time, which occurs after each reply is transmitted, (*b*) 'bunching' of pulses from different pairs causing spurious replies by the transponder. An analysis of the characteristics determines how the time of initial search for a transponder reply and the memory of previous replies are affected by the number of interrogations received by a transponder. Results of actual tests confirm that the equipment satisfactorily complies with I.C.A.O. specifications. See also 365 of February.

621.396.933 1919

Principles Common to Certain Systems of Radio Navigation, and Study of a Particular Case: the Raydist System.—J. Rabier. (*Ann. Télécommun.*, April 1950, Vol. 5, No. 4, pp. 137–142.) Discussion of systems depending on knowledge of the velocity of propagation of e.m. waves. The Raydist system was noted in 3131 of 1947.

621.396.933 R.T.C.A. 1920

The Radio Technical Commission for Aeronautics—its Program and Influence.—J. H. Dellinger. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 468–470.) 1949 I.R.E. National Convention paper.

621.396.9 1921

Frequency-Modulated Radar. [Book Review]—D. G. C. Luck. Publishers: McGraw-Hill, New York, 1949. 466 pp., $4.00. (*Electronics*, May 1950, Vol. 23, No. 5, p. 132.) Written originally as a U.S. Navy report, this book deals with basic theory, design and applications. Military systems take up a substantial portion, and some of the equipment discussed was not completed until after the war. For certain single-target problems f.m. has advantages over pulse radar; for multi-target problems further development is required.

MATERIALS AND SUBSIDIARY TECHNIQUES

531.787.9 1922

The Pirani Effect in a Thermionic Filament as a Means of Measuring Low Pressures.—L. Spiers & W. P. Jolly. (*Brit. J. appl. Phys.*, May 1950, Vol. 1, No. 5, pp. 132–133.) Measurements on the tungsten filament of a simple ionization gauge showed that as the pressure P is reduced the filament-heating voltage required to maintain a given filament emission—90 μA in the particular case considered—falls. When the gas used is hydrogen, the relation between heating voltage and $\log P$ is linear. Advantages of a gauge of this type are enumerated.

535.215 1923

Photoconductivity of Lead Sulphide.—L. Genzel & H. Mörser. (*Z. Phys.*, Jan. 1950, Vol. 127, No. 3, pp. 194–200.) Previous work on the internal photoeffect of PbS in the infra-red region is extended towards shorter waves; experimental results are discussed.

535.215.4 : 546.289 1924

Photoelectric Effects in Germanium.—B. J. Rothlein & F. A. Stahl. (*Sylvania Technologist*, April 1950, Vol. 3, No. 2, pp. 8–11.) Theories and experimental results on the photosensitivity of Ge in the wavelength range 0.5–2 μ are reviewed and the relation of the photosensitivity to the properties of the surface layers of the semiconductor is discussed. An a.c. photoswitch is described in which the power supplied to a dissipative load is controlled by an infra-red beam.

537.581 + 537.324 1925

Refractory Thermocouples and Emissivity Determination.—F. H. Morgan. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 353.) Summary of American Physical Society 1950 Annual Meeting paper EP9. The thermoelectric power was investigated for thermocouples of W/Ta, W/Mo, Ta/Mo, W/W-Mo up to temperatures of 3 000°C or near. The curve found for W/Ta, which was checked, differed from that previously recorded. Using these thermocouples, the spectral emissivity of thoria and other cathode materials was easily found.

537.581 : 546.92 1926

Effect of Impurities on Thermionic Emission from Platinum.—A. Ertel. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, pp. 353–354.) Summary of American Physical Society 1950 Annual Meeting paper EP10. An account of measurements of thermionic work function and emission constant for No. 1 grade and C.P. platinum. The former contained an electropositive impurity which, on receiving heat treatment, was 'cleaned up' at 1 850°–1 930°K; the latter contained both a similar impurity and another which yielded violent bursts of emission at 900°–1 100°K. Spectroscopic and X-ray diffraction analyses were also made.

537.581 : 666.76 1927

Certain Refractory Compounds as Thermionic Emitters.—D. L. Goldwater & R. E. Haddad. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 353.) Summary of American Physical Society 1950 Annual Meeting paper EP8. Some nitrides, borides and carbides are investigated and compared with thoria.

537.582 : 546.3 1928

A Preliminary Study of the Work Function of Contaminated Metal Surfaces.—P. H. Miller, Jr. & B. J. Rothlein. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 354.) Summary of American Physical Society 1950 Annual Meeting paper EP13. An electron beam is passed between a reference plate and the test surface (Ta, Zr or W); changes of work function produce field changes causing deflection of the beam. Changes of 0.05 V can be measured.

538.221 1929

Symposium of Papers on Ferromagnetic Materials.—(*Proc. Instn elect. Engrs*, Part II, April 1950, Vol. 97, No. 56, pp. 118–274.) Summaries are given of all the papers presented during the four sessions on 7th and 8th November 1949, together with the full text of those not published hitherto.

538.221 1930

***g*-Factors in Ferrite Materials.**—H. G. Beljers & D. Polder. (*Nature, Lond.*, 20th May 1950, Vol. 165, No. 4203, p. 800.) Microwave absorption measurements, using 3.2-cm waves, for ferrites containing various proportions of NiO and ZnO give *g*-factors near 2, in agreement with theory.

538.221 1931

Magnetization in Ferrites.—E. W. Gorter. (*Nature, Lond.*, 20th May 1950, Vol 165, No. 4203, pp. 798–800.) A study of the saturation magnetization of various ferrites with spinel structure.

538.221 1932

Anomalous Behavior of the Dielectric Constant of a Ferromagnetic Ferrite at the Magnetic Curie Point.—F. G. Brockman, P. H. Dowling & W. G. Steinbeck. (*Phys. Rev.*, 1st May 1949, Vol. 75, No. 9, p. 1440.)

546.841-3 + 666.76 **1933**

Notes on Thoria and Other Refractory Materials.—L. J. Croning. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 352.) Summary of American Physical Society 1950 Annual Meeting paper EP1. The chemistry of Th compounds is complex; thoria may contain over 3% impurities, and the 'specific surface' of samples from different sources varies enormously. Experimental work is described on the reaction of thoria with metals, the secondary/primary emission ratio of directly heated thoria cathodes, and the evaporation of a large variety of refractory materials.

546.841-3 : 621.3.011.2 **1934**

Electrical Conductivity of Sintered Thoria.—W. E. Danforth & F. H. Morgan. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 353.) Summary of American Physical Society 1950 Annual Meeting paper EP6. The thoria was studied in vacuo at temperatures up to 1 800°C. Specimens were subjected to currents up to several amperes per cm^2; the resistance variation is essentially linear over this range and may be as low as 1 ohm-cm at 1 200°C after prolonged passage of 10 A/cm^2. Exposure to atmospheric pressure causes de-activation. The effect of activation procedures on resulting activation energies is discussed.

546.841-3 : 621.385.032.216 **1935**

Rate of Disappearance of Thoria from Coated Filaments.—E. Shapiro. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 352.) Summary of American Physical Society 1950 Annual Meeting paper EP2. Dependence of the rate on temperature and emission was studied. A formula is given for the range 2 050°–2 250°K, over which the rate is not affected by the current taken.

546.841-3 : 621.385.032.216 **1936**

Thermal Emissivity Changes of Thoria-Coated Tungsten Filaments.—O. A. Weinreich. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, pp. 352–353.) Summary of American Physical Society 1950 Annual Meeting paper EP3. An investigation with particular reference to the effects of processing. In some cases the changes observed can be correlated with changes of thermionic emission. Emissivity of fresh coatings was increased by high-temperature flashing and by electron bombardment.

621.315.57 : 666.3 : 621.385.032.21 **1937**

Ceramic Heaters and Cathodes for Electron Tubes.—Palumbo. (*See* 2065.)

621.315.59 : 546.28 **1938**

Nucleon-Bombarded Silicon.—K. Lark-Horovitz, M. Becker, R. E. Davis & H. Y. Fan. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 334.) Summary of American Physical Society 1950 Annual Meeting paper OA1. The effect of bombardment on resistivity is investigated experimentally.

621.315.59 : 546.289 **1939**

Impedance Characteristics of Grain Boundaries in High Resistivity *N*-Type Germanium.—N. H. Odell & H. Y. Fan. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 334.) Summary of American Physical Society 1950 Annual Meeting paper OA2.

621.315.59 : 546.289 **1940**

D.C. Characteristics of High-Resistance Barriers at Crystal Boundaries in Germanium.—W. E. Taylor & H. Y. Fan. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 335.) Summary of American Physical Society 1950 Annual Meeting paper OA5.

621.315.59 : 621.385.2 : 621.314.632 : 537.311.33 **1941**

D.C. Characteristics of Silicon and Germanium Point Contact Crystal Rectifiers : Part 2—The Multicontact Theory.—V. A. Johnson, R. N. Smith & H. J. Yearian. (*J. appl. Phys.*, April 1950, Vol. 21, No. 4, pp. 283–289.) An extension of the diode theory which accounts for the observed characteristics of these rectifiers.

621.315.612.4 **1942**

The Ferro-Electricity of Titanates.—G. H. Jonker & J. H. van Santen. (*Philips tech. Rev.*, Dec. 1949, Vol. 11, No. 6, pp. 183–192.) Discussion of the analogy between ferromagnetic phenomena and the piezoelectric properties of Rochelle salt, KH_2PO_4 and $BaTiO_3$. Outlines of a theory applicable to titanate dielectrics are given.

621.318.323.2 : 538.114 **1943**

Magnetic After-Effect in Laminated Coil-Cores in Weak Alternating Fields.—R. Feldtkeller. (*Fernmeldetech. Z.*, April 1950, Vol. 3, No. 4, pp. 112–117.)

621.795 : 621.385.833 **1944**

A Lapping Technique to Improve the Image Quality of Electron Microscope Lenses.—F. A. Hamm. (*J. appl. Phys.*, April 1950, Vol. 21, No. 4, pp. 271–278.)

533.5 + 531.788 **1945**

Vacuum Equipment and Techniques. [Book Review]—A. Guthrie & R. K. Wakerling (Eds). Publishers: McGraw-Hill, New York, 1949, 242 pp., $2.50. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, p. 578; *Rev. sci. Instrum.*, April 1950, Vol. 21, No. 4, p. 381.) Concerned primarily with the development of equipment at the University of California Radiation Laboratory. "While . . . the volume does not cover fully all problems likely to be encountered in vacuum processes . . . workers in high-vacuum electronics should find it to be well worth their attention."

535.37 **1946**

An Introduction to the Luminescence of Solids. [Book Review]—H. W. Leverenz. Publishers: J. Wiley, New York, 1950, 471 pp., $12.00. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, p. 577; *Rev. sci. Instrum.*, April 1950, Vol. 21, No. 4, p. 382). "... the author has wisely chosen to describe phosphors generally in terms of preparations, compositions, structures, and physical characteristics, using individual phosphors to illustrate each feature. In this way, a co-ordinated view of the entire subject is obtained, without sacrificing the utility of adequate descriptions of interesting and useful phosphors . . . Much of the author's original work is presented in this volume, together with extensive references to the available literature (the bibliography contains over 1 000 references) . . . . . it will be invaluable . . . in training future specialists and in aiding scientists who wish to refresh and increase their knowledge of solid matter and its interactions with radiations . . . "

621.318.2 **1947**

Abriss der Dauermagnetkunde (Permanent-Magnet Technology). [Book Review]—J. Fischer. Publishers: Springer Verlag, Berlin, 248 pp., 36 DM or 39 DM (linen bound). (*Electrician*, 14th April 1950, Vol. 144, No. 3748, p. 1205.) A comprehensive treatise intended for students and engineers interested in permanent magnets of any size and application.

MATHEMATICS

517.512.2 **1948**

The Summation of Fourier Series by Operational Methods.—L. A. Pipes. (*J. appl. Phys.*, April 1950,

Vol. 21, No. 4, pp. 298–301.) A method using Laplace transforms is described by means of which graphical representations can easily be obtained of certain functions defined by Fourier series and of practical importance.

681.142 1949

The Electronic Isograph for Roots of Polynomials.—H. O. Marshall, Jr. (*J. appl. Phys.*, April 1950, Vol. 21, No. 4, pp. 307–312.) A polynomial $f(z) = \Sigma a_n z^n$ can be represented by $\Sigma a_n r^n \cos n\theta + j\Sigma a_n r^n \sin n\theta$ and a root occurs when these two terms are simultaneously zero. $\sin n\theta$ and $\cos n\theta$ are generated by a commutator, and potentiometers control the amplitudes corresponding to the coefficients a_n. The sums of the cos and sin terms are applied to the x and y plates respectively of an oscillograph, and r is varied by another potentiometer until the trace passes through the origin, indicating one of the roots; θ is determined by a stroboscopic device. Polynomials of degree 10 or less can be dealt with. Various applications are discussed.

681.142 1950

Principle and Realization of a Mathematical Machine, the 'Opérateur Mathématique Électronique' (O.M.E.).—B. A. Sokoloff. (*Ann. Télécommun.*, April 1950, Vol. 5, No. 4, pp. 143–159.) A detailed account of equipment noted in 1443 of June (Raymond)—Type OME 111.

681.142 1951

An Analog Computer.—J. G. Bayly. (*Rev. sci. Instrum.*, March 1950, Vol. 21, No. 3, pp. 228–231.) An integrator capable of solving equations of the form $dx/dt = -\lambda x + f(t)$.

681.142 1952

High Speed Digital Computers.—L. N. Ridenour. (*J. appl. Phys.*, April 1950, Vol. 21, No. 4, pp. 263–270.) An elementary survey of present developments and future trends.

681.142 1953

A Dynamically Regenerated Electrostatic Memory System.—Eckert, Lukoff & Smolar. (*See* 2005.)

681.142 : 517.946.8 1954

Solution of Partial Differential Equations with a Resistance Network Analogue.—G. Liebmann. (*Brit. J. appl. Phys.*, April 1950, Vol. 1, No. 4, pp. 92–103.) A more extended account of the network and iteration method noted in 3460 of 1949. The network described is axially symmetrical, with 60 meshes in the z-direction and 20 in the r-direction, and has 50 current-feeding points. Accuracies to within 1 part in 10^3–10^4 can be attained much more quickly than by numerical methods of field plotting, and semi-skilled operators can handle the equipment satisfactorily.

681.142 : 517.946.8 1955

The Analog Solution of Simultaneous Partial Differential Equations by means of Passive and Active Electrical Networks.—J. H. Green, Jr. & V. B. Corey. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 328.) Summary of American Physical Society 1950 Annual Meeting paper HA7.

681.142 : 621.3.016.352 1956

Stabilization of Simultaneous Equation Solvers.—G. A. Korn. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, p. 514.) Discussion on 3348 of 1949.

681.142 : 621.385.032.212 1957

The Dekatron.—Bacon & Pollard. (*See* 2066.)

681.142 : 621.392 1958

Diode Coincidence and Mixing Circuits in Digital Computers.—Tung Chang Chen. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 511–514.) "Basic circuits utilizing germanium diodes in electrically pulsed systems are described. The circuits are of the following types: (*a*) coincidence circuits—output signal occurs only when all the inputs receive signals simultaneously; (*b*) mixing circuits—output signal occurs when any one of the inputs receives a signal. The analyses of transient response of the output signal and input impedance are given." Pulse-repetition rates up to several Mc/s and rise and fall times of 0.05 μs are possible.

681.142 : 794.1 1959

Programming a Computer for Playing Chess.—C. E. Shannon. (*Phil. Mag.*, March 1950, Vol. 41, No. 314, pp. 256–275.) Full text of the paper noted in 1703 (f) of 1949. Has theoretical interest in relation to more practical problems such as concern machines for designing filters and switching circuits.

MEASUREMENTS AND TEST GEAR

537.291.082.1 1960

A Dynamic Electron-Trajectory Tracer.—J. W. Clark & R. E. Neuber. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 521–524.) The electrode structure in a sheet-rubber model is made to oscillate vertically, thus simulating the effect of applied r.f. voltage.

621.3.018.4(083.7) : 621.396.615.17/.18 + 621.317.761 1961

Frequency Generation and Measurement.—H. J. Finden. (*Electronic Engng*, June 1950, Vol. 22, No. 268, pp. 220–226.) Illustrated description of a frequency synthesizer covering the range 1 kc/s–1 Mc/s in 1-kc/s steps in a decade arrangement, and delivering 0.1 V into a 100-Ω load. A standard controlling frequency of 100 kc/s is obtained from a crystal maintained at 60 °C; this is fed to amplifier and multivibrator circuits to produce oscillations at 1 kc/s, 10 kc/s, 100 kc/s and 1 Mc/s respectively, the lowest of these determining the minimum size of the variation step. The procedure for generating a required frequency, by selecting and combining appropriate harmonics, is given in detail.

621.317 : 061.3 1962

Instruments and Measurements Conference, Stockholm, 1949.—(*Instrum. Practice*, Nov. 1949, Vol. 4, No. 1, pp. 25–33.) Titles and authors are given of all the papers presented, with abstracts of those in English.

621.317.336/.34 + 621.392.6.029.63 1963

Theory and Technique of Multipole Networks at Ultra-High Frequencies.—Goudet & Jassin. (*See* 1882.)

621.317.35 : 621.314.2.029.3 1964

Test Methods for High-Quality Audio Transformers.—E. B. Harrison. (*Tele-Tech*, March 1950, Vol. 9, No. 3, pp. 40–41, 65.) Square-wave inputs are applied at seven frequencies in the range 20 c/s–20 kc/s. The effect of winding resistance, leakage inductance and reflected primary impedance on the output waveform is discussed. Results obtained at the different frequencies with five commercial transformers are illustrated.

621.317.373 : 621.317.755 1965

Phase-Angle Measurements using a Cathode-Ray Tube.—F. A. Benson & A. O. Carter. (*Electronic Engng*, June 1950, Vol. 22, No. 268, pp. 238–242.) A discussion of errors in c.r.o. measurements due to trace width and presence of harmonics.

621.317.39 : 548.0 : 537.228.1 **1966**

An Arrangement for Indicating Piezo-Electricity of Crystals.—W. G. Perdok & H. van Suchtelen. (*Philips tech. Rev.*, Nov. 1949, Vol. 11, No. 5, pp. 151–155.) Describes apparatus of improved sensitivity for detecting piezoelectric effects in small fragments of crystal. These are placed between two flat electrodes connected in parallel with the tuning circuit of an oscillator which is tuned manually through the range 300 kc/s–30 Mc/s and at the same time modulated in frequency at 100 c/s by means of a vibrating capacitor. The dip in the amplitude of oscillation when tuning through a crystal resonance is detected by a separate valve and produces an audible rattle in a loudspeaker.

621.317.612 : 621.314.2.083 **1967**

On the Measurement of the No-Load Losses of Small 50-c/s Transformers.—L. Medina. (*Elektrotech. u. Maschinenb.*, April 1950, Vol. 67, No. 4, pp. 99–104.) Two methods are described, both giving accurate results. In the first method the losses are determined from the value of a resistor substituted for the transformer winding shunted by a capacitor adjusted to give a minimum total current through the combination, the resistor being adjusted to obtain the same current. An amplifier tuned to 50 c/s ensures adequate sensitivity for operating a moving-coil meter or c.r. indicator. The test transformer is fed from 50-c/s mains through an autotransformer and an isolating transformer with an earthed screen between the windings. The second method uses a simple resonance bridge. Typical results are tabulated. Complete circuit details of the tuned amplifier are given. See also 180 of 1947.

621.317.7 + 621.396.6 + 621.38.001.8 **1968**

Physical Society's Exhibition.—(*See* 1883.)

621.317.72 **1969**

A Millivoltmeter for a Large Range of Frequency and Voltage.—H. te Gude. (*Funk u. Ton*, April 1950, Vol. 4, No. 4, pp. 201–204.) Details of the design of an instrument intended for measurements on broadcast receivers and transmitters, and comprising a 6-stage amplifier, crystal detector, moving-coil meter and capacitance attenuator. Frequency range is 1 kc/s–30 Mc/s; the 11 voltage ranges extend from 1 mV to 1 000 V full scale.

621.317.725 **1970**

VTVM Circuits.—M. C. Selby. (*Electronics*, May 1950, Vol. 23, No. 5, pp. 110–111.) A tabulated survey of basic valve-voltmeter circuits.

621.317.725 **1971**

Negative-Feedback Direct-Voltage Valve Voltmeters.—W. Geyger. (*Arch. tech. Messen*, March 1950, No. 170, pp. T31–T33.) An asymmetric single-triode bridge circuit with heavy negative feedback, the adjustment of which provides 4 ranges between 2 and 200 V without affecting the current drawn from the battery supply. Results of measurement are practically independent of alterations of valve characteristics and supply voltage fluctuations. Two-valve push-pull circuits are also shown, one battery-operated and the other supplied from a.c. mains.

621.317.733 **1972**

High-Frequency Bridge of the Société Anonyme de Télécommunications, for the Measurement of [cable] Impedance Deviations.—G. Fuchs & P. Fenouillet. (*Câbles & Transmission, Paris*, April 1950, Vol. 4, No. 2, pp. 126–132.) Direct-reading instrument operating over the range 50 kc/s–10 Mc/s and giving the real and imaginary parts of impedances near 75Ω to within 1 part in 1 000.

621.317.733 **1973**

A Method of Decreasing the Effect of Earth Admittances in A.C. Bridges.—G. H. Rayner & R. W. Willmer. (*J. sci. Instrum.*, April 1950, Vol. 27, No. 4, pp. 103–104.) The bridge screen is connected to the cathode of a cathode follower, so that its potential follows that of the grid, which is connected to one of the detector terminals and thus has a negligible admittance to earth. The balance condition of the bridge is satisfied although the detector terminals are not at earth potential. Precautions taken to ensure a high input impedance for the cathode follower are described in detail.

621.317.733 : 621.317.794 **1974**

A Bolometer Bridge for Standardizing Radio-Frequency Voltmeters.—M. C. Selby & L. F. Behrent. (*Bur. Stand. J. Res.*, Jan. 1950, Vol. 44, No. 1, pp. 15–30.) The equipment described can be used to measure voltages between 20 mV and 1.9 V at frequencies below 700 Mc/s to an accuracy within ±1%. The equipment may also be used for the direct measurement of r.f. generator voltages, as a standard of r.f. impedance, and for accurate power measurement from 20 μW to 100 mW. Factors limiting the range of voltage measurement are described, and various independent methods are given by which the measured voltage can be checked.

621.317.733 : 621.396.611.21 : 621.3.012.8 **1975**

Measurement of the Equivalent Electrical Circuit of a Piezoelectric Crystal.—A. C. Lynch. (*Proc. phys. Soc.*, 1st May 1950, Vol. 63, No. 365B, pp. 323–331.) The value of the equivalent capacitance is deduced from measurements of the effective series capacitance of the crystal at two frequencies symmetrically disposed about the resonance frequency and differing from it by 0.5–5%. A substitution Schering bridge reading to 0.001 pF is used, connected so as to exclude effects of stray capacitance to earth. With a single resonance frequency the equivalent circuit parameters are measured to within 0.1% and the piezoelectric coefficient calculated to within 0.5%. When there is more than one resonance mode the equivalent circuits for each can be deduced by successive approximations.

621.317.756.089.6 : 621.396.662 **1976**

Design Analysis of a *TM*-Mode Piston Attenuator.—A. B. Giordano. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 545–550.) 1948 I.R.E. National Convention paper. The design of a system consisting of coaxial input and output sections separated by a cylindrical waveguide section operating below cut-off is described. The attenuation, input impedance and voltage s.w.r. are calculated and evaluated numerically for a model designed to operate at 10-cm wavelength. The calculations agree well with experimental measurements for coupling separations ≥ 0.5 cm.

621.317.772 : 621.396.11 **1977**

A Method of Simulating Propagation Problems.—Iams. (*See* 2014.)

621.317.784 **1978**

Absolute Measurement of Microwave Power by Radiation Pressure.—A. L. Cullen. (*Nature, Lond.*, 6th May 1950, Vol. 165, No. 4201, p. 726.) Using the method previously described (1727 of 1949) the deflection observed with a 9.1-cm magnetron transmitter giving 1-μs pulses with a recurrence frequency of about 1 kc/s corresponded to a force of 0.014 dyne, equivalent

to a power of 36 W, as compared with 32 W measured simultaneously but independently by a balanced calorimeter method. Projected further work with the apparatus evacuated may eliminate disturbing effects possibly due to heating.

621.317.79 : 621.396.67 1979

Ripple Tank for Phase-Front Visualization.—(*Electronics*, May 1950, Vol. 23, No. 5, pp. 120, 122.) An analogue method of determining phase-fronts associated with aerial systems. Magnetically driven pin points, representing the aerials, are actuated by an audio oscillator and produce water ripples. These are viewed as a stationary pattern on a ground glass screen above the tank, a synchronously controlled stroboscopic light source being used.

621.396.615 1980

Wide-Range Frequency-Modulated Oscillator.—P. M. Milner. (*Electronics*, May 1950, Vol. 23, No. 5, pp. 118, 144–164.) A reactance valve is used as modulator, frequency variation being achieved by varying modulator grid voltage, without introducing frequency multiplication or conversion. From 15 Mc/s to 40 Mc/s the frequency dependence on modulator grid voltage (from 0 to 2.8 V) is linear to within ± 1%, and the output is 1 V r.m.s. to within ± 5%.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

534.321.9.001.8 1981

Summarized Proceedings of Symposium on Applications of Ultrasonics.—G. Bradfield. (*Proc. phys. Soc.*, 1st May 1950, Vol. 63, No. 365B, pp. 305–322.) This symposium, held on 18th Feb. 1949, included surveys of recent advances in (*a*) the investigation of the fundamental structure of matter, (*b*) telecommunication and allied applications, (*c*) the use of mechanical forces set up by intense waves.

539.16.08 1982

On the Velocity of Discharge Propagation in Externally Quenched Geiger Counters.—C. Balakrishnan & J. D. Craggs. (*Proc. phys. Soc.*, 1st April 1950, Vol. 63, No. 364A, pp. 358–366.) A new method for measuring this velocity is described. The results obtained with argon, hydrogen and neon are shown in graphs and tables, and discharge-propagation mechanisms are discussed briefly.

539.16.08 1983

On the Temperature Dependence of Counter Characteristics in Self-Quenching Geiger-Müller Counters.—O. Parkash & P. L. Kapur. (*Proc. phys. Soc.*, 1st May 1950, Vol. 63, No. 365A, pp. 457–461.)

539.16.08 1984

A Study of Plateau Slopes in Self-Quenching Geiger-Müller Counters.—S. C. Brown & C. Maroni. (*Rev. sci. Instrum.*, March 1950, Vol. 21, No. 3, pp. 241–244.)

539.16.08 1985

Time Lags in Geiger Counters.—A. R. Laufer. (*Rev. sci. Instrum.*, March 1950, Vol. 21, No. 3, pp. 244–251.)

539.16.08 1986

The Electric Field in a Geiger Counter.—A. R. Laufer. (*Rev. sci. Instrum.*, March 1950, Vol. 21, No. 3, pp. 252–254.)

539.16.08 : 621.315.59 1987

A Germanium Counter.—K. G. McKay. (*Phys. Rev.*, 15th Nov. 1949, Vol. 76, No. 10, p. 1537.) Bombardment of the barrier region of a Ge crystal under a point contact by an α-particle produces free electrons and positive holes in the barrier region, which are then swept out by the barrier field aided by the applied field. This effect is applied in a counter using N-type high-back-voltage Ge with a phosphor-bronze point contact. Connected to an amplifier covering the range 100 kc/s–15 Mc/s, this acted as an efficient counter for α-particles. The short rise and recovery times, small sensitive volume and ability to discriminate against β-particles, are advantageous in certain applications.

539.16.08 : 621.396.645 1988

Linear Amplifiers.—Schultz. (*See* 1888.)

620.179.16 1989

Ultrasonic Testing of Gas-Turbine Disks.—(*Metal Progress*, April 1950, Vol. 57, No. 4, pp. 468–472.) Flaw detection using a frequency of 2.25 Mc/s.

621.316.74 : 621.385.38 1990

A Continuously-Operating Thyratron Temperature-Control Device.—Aumont. (*See* 2032.)

621.316.74.076.7 1991

Electronic Temperature Control.—(*Overseas Engr*, May 1950, Vol. 23, No. 271, pp. 352–353.) A description of commercial control equipment for gas- or oil-fired furnaces. Variation of temperature causes movement of a metal vane between two coils, thus changing their inductance and operating a sensitive relay controlling the opening of the fuel valve.

621.317.083.7 1992

Analysis of Errors in a Phase-Shift Angle-Telemetering System.—J. V. Harrington. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, p. 495.) Summary of thesis.

621.317.39 1993

An Electrical Displacement Meter.—A. Douglas. (*Electronic Engng*, June 1950, Vol. 22, No. 268, pp. 215–219.) The design and operation of available mains-frequency e.m. gauges for measuring small physical displacements are discussed, and their shortcomings pointed out. The non-resonant-bridge type has low sensitivity, and while the resonant-bridge type is better in this respect it is difficult to stabilize. A bridged-T circuit was therefore used, having a common point to which the a.c. source (a Colpitts oscillator at 20 kc/s), coil and detector could be earthed. Various practical applications of the instrument are mentioned. A more detailed paper on the subject, by the author and H. Ford, is published as Special Report No. 34 of the Iron and Steel Institute.

621.365.54† 1994

Radio-Frequency Heating in the Fabrication of Precision Machines and Apparatus.—A. Leemann. (*Microtecnic, Lausanne*, Jan./Feb. 1950, Vol. 4, No. 1, pp. 33–36.) Advantages of the r.f. method and practical arrangements for heating small parts are discussed.

621.365.54† 1995

Heating by High-Frequency Fields.—E. C. Witsenburg. (*Philips tech. Rev.*, Dec. 1949, Vol. 11, No. 6, pp. 165–175.) A formula is derived for the heating-coil efficiency, from which it appears that in simple cases the best results are obtained when the frequency is high enough to ensure that the penetration depth is not greater than about $\frac{1}{4}$ the diameter of the object being heated.

621.38 : 621.944 1996

Electronic Mill Control.—(*Elect. Times*, 27th April 1950, Vol. 117, No. 3051, pp. 699–701.) G.E.C. equipment installed 10 years ago in the cold-rolling section of Richard Thomas & Baldwin's Ebbw Vale works is

described. It is designed to ensure constant tension in the strip while the latter is uncoiled, rolled, and recoiled, and its use enables a thick-sheet mill to produce thicknesses suitable for tin plate.

621.38.001.8 : 621.396.6 + 621.317.7 **1997**

Physical Society's Exhibition.—(*See* 1883.)

621.38.001.8 **1998**

Electronics Symposium, 1949.—(*Instrum. Practice*, Oct. 1949, Vol. 3, No. 12, pp. 570–571.) Summaries are given of the following papers presented at the symposium organized by the Electronics Group of the Scientific Instrument Manufacturers' Association, London, 2nd–4th Nov. 1949:

Electronic Instrumentation in Atomic Research.—D. Taylor.

Electronic Amplifiers.—D. L. Banks.

Magnetic Amplifiers.—A. V. Hemingway.

Some Recent Improvements in Electronic Measuring Techniques.—C. H. W. Brookes-Smith & J. A. Colls.

The Measurement of some Transient Phenomena.—H. A. Dell.

An Industrial Servomechanism.—P. H. Briggs.

Co-operative Research at B.S.I.R.A.—A. J. Maddock.

See also 708 of March.

621.383 : 621-526 : 771.37 **1999**

Automatic Exposure Control.—G. Bruck, J. Higgins & J. Ward. (*Electronics*, May 1950, Vol. 23, No. 5, pp. 74–78.) A photoelectric servo device for aperture control on motion-picture and television cameras in aerial work at speeds over 600 m.p.h.

621.384.621.1† **2000**

An Open-Type 800-kV Van de Graaff Generator.—P. Ohlin & O. Beckman. (*Ark. Fys.*, 22nd Oct. 1949, Vol. 1, Part 4, pp. 323–327. In Swedish.) General description of the generator and associated accelerator recently constructed at Uppsala.

621.385.83 **2001**

Electron Optics at High Frequencies and at Relativistic Velocities.—D. Gabor. (*Rev. d'Optique*, April 1950, Vol. 29, No. 4, pp. 209–231. In English.) When d.c. and a.c. fields are considered simultaneously, it is more convenient to represent the field by vector potentials and anti-potentials, particularly for systems with axial symmetry. The equations of motion including the relativistic term are considered for an electron, and the conditions for space and phase focusing are established. The results are applied to the case of a linear accelerator and it is concluded that only field-lenses with Alvarez windows will allow stability to be attained in practice.

621.385.833 **2002**

Note on Potentials Derived from Axial Values in Electron Optics.—F. Berz. (*Phil. Mag.*, March 1950, Vol. 41, No. 314, pp. 209–220.) "The determination of electrode systems which produce a precalculated distribution along the optic axis is examined. It is shown that an analytic potential distribution is completely determined when its values along any arbitrarily small interval on the axis are exactly known. On the other hand if, as usual, the value of the potential along a finite stretch of the axis is prescribed within arbitrarily small but finite limits, this is compatible with an infinity of different potential distributions which can be constructed without any singularity at finite distances, and which can assume prescribed values at any number of points outside the axis of symmetry."

621.385.833 **2003**

Laboratory Modifications in the R.C.A. Model EMC Electron Microscope.—S. G. Ellis. (*Rev. sci. Instrum.*, March 1950, Vol. 21, No. 3, pp. 255–257.) The modifications described are capable of being carried out in any laboratory machine shop, and increase the resolving power nearly to its ultimate value, about 50 Å.

621.398 : 538.74 **2004**

The Admiralty Transmitting Magnetic Compass.—A. Hine. (*Instrum. Practice*, Aug. 1949, Vol. 3, No. 10, p. 456.) A brief survey of the function and possible uses of the instrument. The principle is that of a Wheatstone bridge using the liquid in the master-compass as a resistance path between electrodes mounted on the card and in the bowl. The voltage developed between two points of the bridge depends on the compass setting and is used, after amplification, to operate follow-up equipment feeding as many repeaters as required.

681.142 **2005**

A Dynamically Regenerated Electrostatic Memory System.—J. P. Eckert, Jr, H. Lukoff & G. Smoliar. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 498–510.) 1949 I.R.E. National Convention paper. The fundamental theory is discussed of the processes by which charge patterns representing binary numbers are stored on the screen of a c.r. tube in an e.s. memory system. The influence of c.r. tube parameters and of associated circuits is analysed. Experiments with different systems show that the binary digits, 1 and 0, are best represented by a dot and a circle, the circle being produced by whirling the spot at a high radio frequency.

621.38/.39 **2006**

Advances in Electronics : Vol. 2. [Book Review]—L. Marton (Ed.). Publishers: Academic Press, New York, 1950, 378 pp., $7.00. (*Electronics*, May 1950, Vol. 23, No. 5, pp. 134–135.) Includes 8 new monographs dealing with electron focusing, cathodoluminescence, breakdown in dielectrics, microwave magnetrons, ferromagnetic phenomena and spectroscopy. Vol. 1: 2889 of 1949.

621.38 : 539.17 **2007**

Electronics: Experimental Techniques. [Book Review]—W. C. Elmore & M. L. Sands (Eds). Publishers: McGraw-Hill, New York, 1949, 417 pp., $3.75. (*Electronics*, May 1950, Vol. 23, No. 5, pp. 136–142.) National Nuclear Energy Series, Division V, Vol. 1. "This is not a treatise on experimental electronic techniques; it is a volume describing in detail a series of excellent devices which have been designed, tested and modified until they meet satisfactorily many of the needs of the nuclear physicist." This volume covers the work done at the Los Alamos Laboratories. "The usefulness of this book and its permanent value would have been greatly enhanced if . . . . a more complete treatment had been given of the basic circuit elements . . . ."

621.38.001.8 **2008**

A Symposium on Electronics. [Book Review]—A. G. Peacock (Ed.). Publishers: Chapman & Hall, London, 199 pp., 16s. (*Brit. J. appl. Phys.*, April 1950, Vol. 1, No. 4, p. 110.) A collection of ten papers read at the first symposium on Electronics, held in London in 1948: applications in research and industry are dealt with.

See also 1145 of 1949.

PROPAGATION OF WAVES

538.566 **2009**

The Radiation from a Magnetic Dipole in a Spherically Symmetrical Stratified Medium.—G. Eckart. (*Ann. Télécommun.*, May 1950, Vol. 5, No. 5, pp. 173–178.) Primary radiation over a curved earth is considered for

the case in which the dielectric constant is a function of the radius r of the form $\epsilon = \alpha + \beta/r$. The equation derived for waves with the Fitzgerald potential Π is solved by separation of the variables and a solution is expressed in terms of Green's functions. A second solution for a homogeneous medium under particular conditions is derived. From the two solutions a theorem on hypergeometric functions is deduced. The physical interpretation of the results is briefly discussed.

621.396.11 + 535.222 2010

Velocity of Light and of Radio Waves.—L. Essen. (*Nature, Lond.*, 20th May 1950, Vol. 165, No. 4203, p. 811.) Houston's recent measurement of the velocity of light (1896 above) is noted as being in close agreement with the commonly accepted value of 299 776 km/s and not with other recent determinations by both radio and optical methods. Further careful measurements are needed to establish the value of the velocity. See also 1751 of July.

621.396.11 2011

On the Propagation of Medium Waves over Inhomogeneous Ground.—J. Grosskopf. (*Fernmeldetech. Z.*, April 1950, Vol. 3, No. 4, pp. 118–121.) The decrease in field strength in propagation over ground having different dielectric and conductivity constants along the propagation path, as in the case of successive stretches of land and sea, may be determined by a graphical method from the measured or estimated values of the ground constants, an appropriate modification of the formula for 'numerical distance' being applied. The kinks in the field-strength/distance curve which correspond to land/sea boundaries are interpreted quantitatively. See also 2122 of 1944.

621.396.11 : 535.312] + 538.569.4 2012

Absorption and Reflexion of U.H.F. Waves (300–500 Mc/s) by Sea Water.—Chatterjee & Sreekantan. (*See* 1904.)

621.396.11 : 551.510.535 2013

Radio Wave Propagation in a Curved Ionosphere.—J. M. Kelso. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 533–539.) "Using a double parabola approximation to the Chapman distribution of electron density as a function of height, and the assumption of a curved-ionosphere curved-earth geometry, analytic expressions are obtained for the true height of reflection, ray path, reflection coefficient, ground range and group path. Graphical results are given for the maximum usable frequency factor. Where possible, the above results are compared with results obtained by assuming a plane ionosphere."

621.396.11 : 621.317.772 2014

A Method of Simulating Propagation Problems.—H. Iams. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 543–545.) 1949 I.R.E. West Coast Convention paper. Problems relating to reflection, refraction or scattering can be simulated by propagating cm waves in a large sheet of low-loss dielectric material, conditions being varied by embedding objects in the sheet, altering its thickness or coating its surfaces. One surface of the sheet is then scanned with the probe of a phase-front plotter.

621.396.81 2015

U.H.F. Coverage in Pittsburgh.—R. N. Harmon. (*FM-TV*, May 1950, Vol. 10, No. 5, pp. 14–17.) A field-strength survey has been made by Westinghouse Radio to determine whether the method of calculation proposed by the F.C.C. for very hilly country is satisfactory. Considerable disagreement was found between the theoretical and the observed results.

621.396.81 2016

Microwave Angle Separation on a Two-and-One-Half Mile Overwater Path.—A. W. Straiton & A. H. LaGrone. (*J. appl. Phys.*, March 1950, Vol. 21, No. 3, pp. 188–193.) Three methods were used to measure the angular separation between the direct and water-reflected waves in transmissions across Lake Buchanan, Texas, using a wavelength of 3.2 cm. The separation was $<0.5°$ and the two intensities were nearly equal. The first method depends on measurements of the relative phases and signal strengths at three vertically spaced aerials. The second method requires the relative phases at two aerials and the signal strengths relative to the maximum and minimum signal from a height-gain curve. The third method requires a signal-strength record as the axis of a large parabolic aerial is tilted in the vertical plane containing the incoming rays. The first method is quick and in general accurate; the second is the most accurate, but the necessary height-gain measurements limit its usefulness.

621.397.81 2017

WTTG Field-Strength Survey.—Wakeman. (*See* 2050.)

RECEPTION

621.396.621 : 621.396.822 2018

Design Factors in Low-Noise-Figure Input Circuits.—M. T. Lebenbaum. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, p. 539.) Correction to paper abstracted in 1304 of June.

621.396.621 2019

The Technique of Radio Design. [Book Review].—E. E. Zepler. Publishers: Chapman & Hall, London, 2nd edn 1949, 394 pp., 25s. (*Electronic Engng*, June 1950, Vol. 22, No. 268, p. 254; *Tele-Tech*, April 1950, Vol. 9, No. 4, p. 67; *J. sci. Instrum.*, April 1950, Vol. 27, No. 4, p. 112.) This book, originally published in 1943, deals with the development and testing of all types of radio receiving apparatus, and embodies the first-hand experience gained during many years by a designer in a large works laboratory.

621.396.621 2020

Recent Advances in Radio Receivers. [Book Review].—L. A. Moxon. Publishers: Cambridge University Press, London, 1949, 183 pp., 18s. (*Brit. J. appl. Phys.*, April 1950, Vol. 1, No. 4, p. 110.) One of a series of monographs on radio technique. The treatment is essentially physical, and the problem of receiver noise gets particular attention, the book being concerned mainly with receivers for radar and communications.

STATIONS AND COMMUNICATION SYSTEMS

621.395.47 + 621.396.86 2021

An Improved Speech-Inverter System.—L. L. Koros. (*Electronics*, May 1950, Vol. 23, No. 5, pp. 86–89.) Details with diagrams are given of a privacy circuit for radio or line telephony using an a.f. inversion carrier modulated by the speech input and also controlled in accordance with its average level. An RC equalizer network corrects frequency response. Distortion and background noise levels are low.

621.395.6 : 621.395.44 2022

Carrier-Current and Pilot-Signal Generators Standardized by the Administration Française des P.T.T. for 600-Channel Telephony Links.—H. Dumas & P. Moll. (*Câbles & Transmission, Paris*, April 1950, Vol. 4, No. 2, pp. 150–179.) Illustrated description of the terminal equipment on the Paris-Toulouse-Brive-Bordeaux circuit. Bandwidth is 4 kc/s. Basic frequencies

of 4, 12 and 124 kc/s are derived from a 4-kc/s master oscillator and provide respectively 12 channels between 60 and 108 kc/s, 60 channels between 312 and 552 kc/s, and 600 channels between 60 and 2 540 kc/s or 960 channels between 60 and 4 028 kc/s. Pilot signal frequencies are 60, 300 and 2 604 kc/s. Precautions taken against breakdown include triplication of the master-oscillator unit and duplication of the harmonic-generator/filter/amplifier chain; these are interchanged periodically.

621.396.41 : 621.396.97 **2023**

Multiplex Broadcasting.—E. A. Brettingham-Moore. (*Proc. Instn Radio Engrs, Aust.*, March 1950, Vol. 11, No. 3, pp. 55–62.) The present overcrowding of the 540–1 500-kc/s band in the Sydney area has made it essential to consider the use of new channels. United States experience in the u.h.f. band using pulse-time-division and frequency-division multiplex was reviewed and it was decided that equally good results should be attainable by use of frequency-division multiplex in the 100-Mc/s band. An experimental 2-channel system is described, operating on a main carrier of 91 Mc/s modulated in frequency by two a.m. subcarriers of frequencies 570 and 650 kc/s. The inherent economies of multiplex systems are pointed out.

621.396.619.16 **2024**

The Use of Modulation Converters in Pulse Multiplex Equipment.—G. Potier. (*Onde élect.*, April 1950, Vol. 30, No. 277, pp. 195–199.) Discussion of the principles of converting one type of pulse modulation to another type, particularly as applied to a p.t.m. transmission system in which p.a.m. is used initially. This reduces the number of valves required and limits the effects of overmodulation. General descriptions are given of a sawtooth waveform generator operating as a converter and a method of receiving p.p.m. signals with equipment designed for p.t.m.

621.396.65 : 621.396.619.16 **2025**

An Installation for Multiplex Pulse Modulation.—C. J. H. A. Staal. (*Philips tech. Rev.*, Nov. 1949, Vol. 11, No. 5, pp. 133–144.) The requirements which have led to the use of multiplex (time-sharing) p.m. cm-wave equipment in certain radio links for telephone services are discussed. An 8-channel p.t.m. system is described, with detailed discussion of the channel-selection circuits. An original feature of the receiver is the use of a valve with secondary-emission cathode in an anode-follower circuit to convert the received pulse samples of the audio waveform into a stepped replica of the waveform itself.

621.396.65 : 621.397.5 **2026**

Television Radio-Relay Links.—A. H. Mumford & C. F. Booth. (*P.O. elect. Engrs' J.*, April 1950, Vol. 43, Part 1, pp. 23–35.) A survey of the problems governing the choice of the system to be used in a television relay radio link and a statement of the requirements which have to be met, with brief details of an experimental 200-Mc/s single-frequency link between London and Cardiff and a full description of the London/Birmingham relay system. See also 471 of February.

621.396.712 : 534.86 **2027**

Audio-Frequency Equipment for Broadcasting Services.—J. E. Telfer. (*Proc. Instn Radio Engrs, Aust.*, May 1950, Vol. 11, No. 5, pp. 107–123.) Studio design is discussed and the special features of suitable equipment are described, including that of typical control rooms. A summary of permissible tolerances in frequency response, distortion, signal/noise ratio, and crosstalk level is given.

621.396.712 : 534.86 **2028**

Developments in Studio Design.—Beranek. (*See* 1847.)

SUBSIDIARY APPARATUS

621-526 **2029**

Analysis of a Sampling Servo Mechanism.—K. S. Miller & R. J. Schwarz. (*J. appl. Phys.*, April 1950, Vol. 21, No. 4, pp. 290–297.)

621-526 **2030**

Theory of Nonlinear Servomechanisms.—J. R. Dutilh. (*Radio franç.*, May 1950, No. 5, pp. 1–7.)

621.316.74 **2031**

A Thermostat Control Unit.—H. A. Vodden. (*J. Soc. chem. Ind., Lond.*, Feb. 1950, Vol. 69, No. 2, pp. 51–52.) A thermistor is used as the sensing element. The output from the thermistor bridge network, after amplification, provides grid-voltage control of the current in a gas-filled triode, the anode circuit of which contains the heating element. Temperature fluctuations are <0.01° in the range 20°–70°C and <0.025° up to 120°C.

621.316.74 : 621.385.38 **2032**

A Continuously Operating Thyratron Temperature-Control Device.—R. Aumont. (*Rev. gén. Elect.*, April 1950, Vol. 59, No. 4, pp. 175–178.) A bridge circuit is described in which the unbalance voltage produced by the temperature variation is applied, after amplification, to the thyratron grid. Arrangements are provided for ensuring the correct phase relation between this voltage and the invariable component of the grid voltage. The thyratron supply is taken from a separate source, this being important where high power is handled. A large temperature range is covered by simple adjustments.

TELEVISION AND PHOTOTELEGRAPHY

621.397.5 : 621.396.65 **2033**

Television Radio-Relay Links.—Mumford & Booth. (*See* 2026.)

621.397.5 : 621.396.67 **2034**

High-Gain and Directional Antennas for Television Broadcasting.—Wolf. (*See* 1865.)

621.397.5 : 621.317](083.74) **2035**

Standards on Television: Methods of Measurement of Television Signal Levels, Resolution, and Timing of Video Switching Systems, 1950.—(*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 551–561.) I.R.E. Standard 23.S1 outlining suitable methods.

621.397.6 **2036**

Commercial Television at U.H.F.—J. H. Battison. (*Tele-Tech*, March 1950, Vol. 9, No. 3, pp. 48–..69.) For an abstract of another account see 1795 of July (Guy, Seibert & Smith).

621.397.6 **2037**

High-Performance Television Monitors.—J. E. B. Jacob. (*J. Brit. Instn Radio Engrs*, April 1950, Vol. 10, No. 4, pp. 158–175.) A performance specification which should be met by a transmission station vision monitor is outlined. The use of stereographic projection to minimize picture distortion, and of spot wobbling to render the line structure less visible, is recommended. A monitor designed for the B.B.C. and incorporating most of the features discussed is described.

621.397.6 **2038**

Television Synchronizing Generator.—G. Zaharis. (*Electronics*, May 1950, Vol. 23, No. 5, pp. 92–95.) "Standard synchronizing, blanking, horizontal and vertical driving signals are obtained from a generator

based upon binary counters without variable controls. Synchronizing-signal parameters are fixed by circuit configuration rather than by RC or charge-accumulation circuits. Stability is high and independent of power supply regulation." Circuit diagrams of the whole system are included.

621.397.6 2039

Synchronization for Colour-Dot Interlace in the R.C.A. Colour-Television System.—(*J. Brit. Instn Radio Engrs*, April 1950, Vol. 10, No. 4, pp. 128–136.) Synchronization problems are discussed and means of obtaining colour-dot interlacing with a simplified receiver construction are outlined. A modification of the horizontal synchronizing pulse is required but this does not affect the operation of monochrome receivers. The necessary alterations to present transmitter equipment are described.

621.397.611.2 2040

The Vidicon Photoconductive Camera Tube.—P. K. Weimer, S. V. Forgue & R. R. Goodrich. (*Electronics*, May 1950, Vol. 23, No. 5, pp. 70–73.) 1950 I.R.E. Convention paper. Photoconductive and photoemissive targets for television pickup tubes are compared. A tube one inch in diameter and six inches long, with a photoconductive target, is described and its operating characteristics and sensitivity are given. Simplicity of design, high sensitivity and good resolution make it suitable for industrial applications as well as for broadcasting use.

621.397.611.2 2041

Television Camera Tubes.—(*Wireless World*, May 1950, Vol. 56, No. 5, pp. 162–165.) A short illustrated account of the operation of image orthicons and discussion of manufacturing problems.

621.397.611.2 2042

The Marconi Mobile Camera Chain.—(*J. Televis. Soc.*, Dec. 1949, Vol. 5, No. 12, pp. 363–366.) The equipment comprises camera, electronic viewfinder, camera control and preview monitor, and regulated power supply. The characteristics of the various units are summarized and a short explanation of the operating principles and construction of the Type-5655 image orthicon is given.

621.397.62 2043

Deflector Coil Characteristics.—W. T. Cocking. (*Wireless World*, March–May 1950, Vol. 56, Nos. 3–5, pp. 95–97, 147–151 & 176–179.) A discussion of the performance of the main types, with special reference to their efficiency. The most efficient deflector coil is the one that produces the least external field for a given internal field. For reasonable efficiency an iron circuit is essential: the two basic forms are the iron-ring and the iron-core; a hybrid version in which the iron acts as ring for the line coils and core for the frame coils has also been used. Tables are given showing LI^2, RL and RI^2 for a number of radar coils and for a set of specially made coils. From comparison of experimental results the iron-ring type with bent-up-end coils is best for both line and frame scan.

621.397.62 2044

More about Spot Wobble.—T. C. Nuttall. (*Wireless World*, March 1950, Vol. 56, No. 3, pp. 189–191.) Explanation of the way in which spot-wobble operates and discussion of its application to improve the recording of television pictures on film, to reduce screen-saturation effects in high-power c.r. tubes for large-screen projection, and to remove lininess from large, bright, directly viewed television pictures. See also 1541 of June (Hallows).

621.397.62 : 535.88 2045

A 15- by 20-Inch Projection Receiver for the R.C.A. Colour Television System.—(*J. Brit. Instn Radio Engrs*, April 1950, Vol. 10, No. 4, pp. 137–151.) A detailed description is given of an improved receiver in which conventional r.f., i.f., and a.f. circuits are used and a reflector system replaces the refractive system previously used, greater brightness being obtained. Picture reproduction is effected by means of separate green-, red-, and blue-phosphor projection tubes suitably located with respect to a pair of crossed dichroic mirrors, a 45° mirror and a viewing screen. A sampling procedure is used for sequential operation of the three tubes. Detailed circuit diagrams are given.

621.397.62 : 621.396.662 2046

Broad-Band Television Tuners.—A. Newton. (*Electronics*, May 1950, Vol. 23, No. 5, pp. 102–106.) An i.f. above 30 Mc/s is chosen, so that the image spectrum falls well outside the television bands; the r.f. stage can then be designed to have a single pass-band wide enough to accept all the television channels and sufficiently selective to reject all image signals. Station selection is accomplished by tuning the local oscillator only, and the i.f. selectivity eliminates adjacent channel interference. Various alternative circuits are compared from the point of view of gain and noise.

621.397.621.2 : 535.371.07] : 535.88 2047

The "Double-Layer" Projection Tube Screen for Television.—M. Sadowsky. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 496–498.) 1949 I.R.E. Electronic Conference paper. An account of the development of a screen with good efficiency and little colour shift with change of beam current.

621.397.645 2048

Wide-Band Chain Amplifier for TV.—W. V. Tyminski. (*Radio & Televis. News, Radio-Electronic Engng Supplement*, April 1950, Vol. 14, No. 4, pp. 14–16, 29.) A description of an amplifier with a bandwidth of 200 Mc/s, covering all television and f.m. bands and suitable for connecting several receivers to a single aerial system. The amplifier is analogous to a lumped-constant transmission line, of characteristic impedance 180 Ω, in which some components are valves. A gain of 9 db is obtained from an amplifier stage with six valves. Further gain is best obtained by arranging two or more stages in cascade. See also 594 and 595 of February (Kennedy & Rudenberg).

621.397.7 2049

Bridgeport U.H.F.-TV Test Results.—R. F. Guy. (*FM-TV*, May 1950, Vol. 10, No. 5, pp. 11–13.) A first report of results obtained in 1 000 hours of operation.

621.397.81 2050

WTTG Field-Strength Survey.—R. P. Wakeman. (*Tele-Tech*, March 1950, Vol. 9, No. 3, pp. 27–29, 70.) Continuous field-strength measurements along eight roughly equispaced radials, with the transmitter as centre, show the distribution to be normal for 10 representative distances up to 40 miles. The standard deviation decreases systematically with increase of distance from the transmitter; the Ad Hoc Committee, owing to lack of evidence, assumed no such variation.

621.397.82 : 621.326 2051

Interference from Incandescent Lamps.—W. S. Mortley. (*Electronic Engng*, May 1950, Vol. 22, No. 267, p. 206.) Comment on 771 of March (D.G.F.).

621.397.828 2052

Some Devices for Reducing the Effects of Fading and Interference: Part 2.—D. McMullan. (*J. Televis. Soc.*, Dec. 1949, Vol. 5, No. 12, pp. 339–348.) Means of reducing the effect of impulsive interference are discussed. These include limiting, 'black spotting' and a scheme in which the scanning spot is maintained at the brightness it had immediately prior to the interference. The circuit of such an interference suppressor interposed between the video amplifier and c.r. tube is given. The effect of fluctuation noise on synchronization and means of improving synchronization are described. The use of a.g.c. to minimize flutter due to aircraft and the use in future of a negative-modulation system are advocated. Part 1: 1278 of May.

621.397.828 : 621.396.61 2053

Eliminating TVI in your Ten-Meter Transmitter.—S. Kupferman. (*CQ*, May 1950, Vol. 6, No. 5, pp. 18–21 ..54.) An account of practical measures taken by an amateur to prevent his set from causing interference in nearby television receivers.

TRANSMISSION

621.396.61 : 621.397.828 2054

Eliminating TVI in your Ten-Meter Transmitter.—Kupferman. (*See* 2053.)

VALVES AND THERMIONICS

621.327.43.032.216 2055

A Study of Cathode Behavior in Fluorescent Lamps.—E. F. Lowry, E. L. Mager & H. H. Homer. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 355.) Summary of American Physical Society 1950 Annual Meeting paper EP21. Addition of about 5% of ZrO_2 to the usual oxides of a cathode coating increased life by nearly 200% to 7 500 hours rating, and greatly reduced production of spots and rings of discolouration on the tube wall. If ZrO_2 is added in excess, the blackening is greater than when it is not used at all.

621.383 2056

Investigations of the Pulse Distribution of an R.C.A. Multiplier Phototube.—R. Westöö & T. Wiedling. (*Ark. Fys.*, 22nd Oct. 1949, Vol. 1, Part 4, No. 10, pp. 269–280. In English.)

621.385 : 621.326.662.6 2057

Investigation of Contaminants in Vacuum Tubes.—P. D. Williams. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 353.) Summary of American Physical Society 1950 Annual Meeting paper EP7. Mass-spectrometer studies have been made to identify volatile substances released at processing temperatures by glasses, ceramics, and quartz.

621.385 : 621.396.61 2058

A Survey of Modern Radio Valves: Part 4—Transmitting Valves for Use up to 30 Mc/s.—K. D. Bomford & A. H. F. Hunt. (*P.O. elect. Engrs' J.*, April 1950, Vol. 43, Part 1, pp. 10–15.) A discussion of design and construction, with particular reference to materials used and means adopted for dissipating heat during operation. Part 3: 1291 of May.

621.385.029.63/.64 2059

A Low-Noise Traveling-Wave Tube.—S. W. Harrison. (*Sylvania Technologist*, April 1950, Vol. 3, No. 2, pp. 12–16.) The design described was developed as the result of research on noise reduction. Reconsideration of theory of operation and allowance for both velocity and current fluctuations in the beam entering the helix led to a reduction of helix operating potential and beam current, the electron gun being modified to produce a 'smooth' parallel beam. The operating characteristics are, for a helix potential of 650 V and a beam current of 140 μA: gain 25 db, noise figure 14 db, bandwidth 800 Mc/s centred on 3 000 Mc/s. The method of noise measurement is described in some detail.

621.385.029.63/.64 2060

Development of Travelling-Wave Amplifiers with a Helical Coil: General Results.—A. Blanc-Lapierre & M. Kuhner. (*Ann. Télécommun.*, Aug./Sept. 1948, Vol. 3, Nos. 8/9, pp. 259–264.) Relevant problems of electron optics, interaction between field and electron beam, measurement of attenuation and velocity of propagation along the helix, and matching methods, are discussed. Measurements were made on valves with helices of different material and dimensions. Construction of the final type is described in detail; two variants of this were made, (*a*) with a helix of 5.8 mm diameter, of 0.5-mm Armco wire, (*b*) with a helix of smaller diameter. Both operate at 1 500 V, with a bandwidth of the order of 100 Mc/s centred at 3000 Mc/s. For low inputs the gain of (*a*) is 12–15 db, that of (*b*) about 20 db.

621.385.029.63/.64 2061

Interaction Phenomena in the Travelling-Wave Valve: Theory and Experimental Verification.—P. Lapostolle. (*Ann. Télécommun.*, Aug./Sept. 1948, Vol. 3, Nos. 8/9, pp. 265–290.) The theory given in the first part takes account of the complete distribution of the e.m. fields in the beam and is applicable to any delay line. It indicates that the gain of the valve increases with current and tends to a limit which is a function of the diameter of the beam and the nature of the line. The essential characteristics of a valve may be predetermined experimentally by measuring the deceleration of the wave produced when the beam is replaced by a dielectric rod; this measurement can be performed in air. Gain and saturation level are calculated. In the second part this theory is applied to the helix type of valve, the helix being replaced by a helically conducting metal cylinder, for which the calculations are simpler. Experimental results are given which confirm the theory in respect of propagation characteristics, gain and power. Characteristic impedance and attenuation are calculated for the helix circuit.

621.385.029.63/.64 2062

Experimental Determination of the Characteristics of Travelling-Wave Amplifiers: Results Obtained.—R. Wallauschek. (*Ann. Télécommun.*, Aug./Sept. 1948, Vol. 3, Nos. 8/9, pp. 300–308.) The measurement apparatus, comprising a calibrated generator and 2 wattmeters for input and output power, is described, the coupling arrangements being particularly considered. Measurements were made of the attenuation, gain, output power, etc. of the two valves noted in 2060 above. Limiting power for linear operation was 130 and 60 mW, gain 11.5 and 21 db, noise factor 24 and 25 db respectively.

621.385.029.63/.64 ; 621.3.09 2063

Experimental Study of the Propagation along a Delay Line in the Form of a Helix.—Jessel & Wallauschek. (*See* 1859.)

621.385.029.63/.64 : 621.396.615.141.2 2064

The Magnetron-Type Traveling-Wave Amplifier Tube.—R. R. Warnecke, W. Kleen, A. Lerbs, O. Döhler & H. Huber. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 486–495.) The low efficiency obtainable with travelling-wave amplifiers is due to the fact that only the energy corresponding to the difference between

the electron velocity and the wave velocity can be extracted from the beam. This difference is of necessity small. A new valve is described in which a magnetic field constrains a ribbon-shaped electron beam to travel at right angles to a static electric field. A travelling wave on a delay line parallel to the beam bunches the beam in width and extracts energy from it. Measurements on experimental valves of this type substantiate the theory, although the high efficiency and power output possible have not been reached in the early designs.

621.385.032.21 : 621.315.57 : 666.3 2065

Ceramic Heaters and Cathodes for Electron Tubes.—T. R. Palumbo. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 356.) Summary of American Physical Society 1950 Annual Meeting paper EP27. Preformed rods of a ceramic such as Al_2O_3 are exposed to a hydrocarbon atmosphere, e.g. methane, at 700°–900°C; a ceramic/carbon compound results which is conductive and has a negative temperature coefficient of resistance and high current-carrying capacity; these conductive ceramics are used for valve cathodes or cathode heaters.

621.385.032.212 : 681.142 2066

The Dekatron.—R. C. Bacon & J. R. Pollard. (*Electronic Engng*, May 1950, Vol. 22, No. 267, pp. 173–177.) A range of multi-electrode cold-cathode tubes, on octal or miniature bases, has been designed for use in electronic counting and computing machines. The three types at present designed are: (*a*) a scale-of-ten tube on octal base, for direct viewing, (*b*) a miniature scale-of-ten tube on a B7G base for frequency division or gate operation, (*c*) a tube of similar size to that of (*a*), with multiple connections for obtaining any of several scaling factors. The action of these tubes resembles in some respects that of the tube described by Lamb & Brustman (266 of January). A cathode glow discharge on one of a set of interconnected cathodes arranged around a central anode is caused to transfer from one position to the next by the application of controlling pulses to auxiliary intermediate electrodes. The transfer cycle may be clockwise or counter-clockwise at will. Simple circuits for operating the tubes are described. A maximum counting rate of the order of 600 cycles/second is recommended, but greatly increased operating speeds are envisaged.

621.385.032.216 2067

The Potential Distribution in Pulsed Oxide-Coated Cathodes and its Consequences for the Velocity Distribution of the Emitted Electrons.—R. Loosjes, H. J. Vink & C. G. J. Jansen. (*J. appl. Phys.*, April 1950, Vol. 21, No. 4, pp. 350–351.) Continuation of investigations noted in 2414 of 1948 and 491 and 1302 of 1950. Electron emission velocity was examined by an e.s. deflection method. The velocities were in most cases more or less concentrated in two or sometimes three groups instead of being continuously distributed. The reason for this is not yet understood.

621.385.032.216 2068

The Electronic Temperature of Oxide Cathodes: Methods of Measurement and Results.—R. Champeix. (*Le Vide*, March 1950, Vol. 5, No. 26, pp. 763–768.) The usual method of calculating the electronic temperature T is to make use of the residual-current/voltage curve, the analytical expression of which is an equation analogous to that of Boltzmann. Because of possible errors in the measurements on which this curve is based, the value of T is liable to an error of 5–10%. A more accurate and rapid method is described in which T is deduced from the internal resistance of the diode formed by the cathode and grid or anode, which is measured by connecting the valve in a phase-compensation bridge circuit; possible errors are < 2%. Results show that T is always higher than the thermodynamic temperature and the difference is greater the lower the temperature and the better the cathode is activated. The results are interpreted by assuming a reflection coefficient which is the greater the lower the electron velocity. See also 1303 of May.

621.385.032.216 2069

Preparation of Thoria Cathodes by Cataphoresis.—G. Mesnard & R. Uzan. (*Le Vide*, March 1950, Vol. 5, No. 26, pp. 769–776.) A carefully cleaned tungsten wire of diameter 0.15 mm, acting as the cathode of the system, is suspended along the vertical axis of a cylindrical anode of diameter 5 cm immersed in a bath of absolute alcohol with pure thoria in suspension and/or thorium nitrate with a little water. Illustrations are given of the coating on the wire after exposure for different periods in the six baths used and for various currents. Factors affecting the adherence and character of the deposit are discussed.

621.385.032.216 2070

An Investigation of Magnesium as an Additive to the Nickel Base of an Oxide Cathode.—R. Forman & G. F. Rouse. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 355.) Summary of American Physical Society 1950 Annual Meeting paper EP18. Techniques for adding Mg to electrolytic Ni were developed and the rate of diffusion of the Mg through the Ni was studied. The thermionic properties of different cathodes were compared in a planar double diode. Under certain conditions cathodes activate more rapidly on a Ni base than on a Mg-Ni base.

621.385.032.216 : 537.533 2071

On the Interpretation of Conduction and Thermionic Emission of (Ba-Sr)O Cathodes.—F. K. du Pré, R. A. Hutner & E. S. Rittner. (*Phys. Rev.*, 1st June 1950, Vol. 78, No. 5, pp. 567–571.) "A new semiconductor model for (Ba-Sr)O cathodes is proposed comprising a conduction band, donor levels, acceptor levels, and a full band. The combination of this model with the Vink-Loosjes concept of conduction by an electron gas in the pores of the oxide coating appears to explain in a natural way many of the existing experimental facts pertaining to the conductivity and thermionic emission of these cathodes."

621.385.032.216 : [537.582 + 621.3.011.2 2072

Thermionic Emission, Conductivity, and Contact Potential Difference Measurements.—W. J. Price. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 354.) Summary of American Physical Society 1950 Annual Meeting paper EP14. Description of a special vacuum tube and method devised for investigating all three properties for the same cathode. Thoria-coated cathodes were studied; conductivity was proportional to thermionic emission over a considerable temperature range and for widely different conditions of activation. The change in work function following activation was found the same by thermionic-emission measurements and by contact-potential measurements.

621.385.032.216 : 537.583 2073

Thermionic Properties of Dense Oxide Cathodes.—J. A. Burton, H. E. Kern & R. T. Lynch. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 355.) Summary of American Physical Society 1950 Annual Meeting paper EP20. Variation of thermionic properties with cathode temperature and with anode voltage applied for periods ranging from 1 μs to 1 000 sec was investigated

by means of test diodes. Results are compared with those to be expected from an ideal diode of similar geometry under various conditions. For pulses short enough for decay effects to be negligible, the observed slopes of Schottky plots agree closely with those to be expected for a patch-free surface.

621.385.032.216 : 546.74 2074

Effects of Controlled Impurities in Nickel Core Metal on Thermionic Emission from Oxide-Coated Cathodes.—H. Jacobs, G. Hees & W. Crossley. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 356.) Summary of American Physical Society 1950 Annual Meeting paper EP28. An investigation of the suitability of 18 Ni alloys as cathode bases. The best are Al-Ni, Cr-Ni, Mo-Ni, Th-Ni; the poorest are B-Ni, Be-Ni, Fe-Ni.

621.385.032.216 : [546.841-3 + 546.719 2075

Thermionic Emitting Properties of Thoria-Rhenium.—G. A. Espersen. (*J. appl. Phys.*, March 1950, Vol. 21, No. 3, p. 261.) Cathode rods containing equal amounts of thoria and rhenium gave an emission of about 55 mA/cm² at 1 630 °K and 1.2 A/cm² at 2 040 °K, the corresponding values for a similar thoria/tungsten rod being 0.2 mA/cm² and 0.88 A/cm². After 150 hours test at 2 040 °K the amount of material deposited inside the glass envelope was greater for the thoria-tungsten cathodes.

621.385.032.216 : 546.841-3 2076

Experimental Use of Thoria Cathodes in High-Voltage Rectifier Tubes.—S. T. Yanagisawa & T. H. Rogers. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 353.) Summary of American Physical Society 1950 Annual Meeting paper EP4. The effect on the cathodes of very high back voltage was investigated by incorporating them in h.v. rectifiers for X-ray work. Cathode life, emission efficiency, and the effect of thoria evaporation in particular were examined. The results indicate that thoria cathodes may be used in valves rated up to 110 kV peak.

621.385.032.216 : 546.841-3 2077

Base-Metal Effects in Thoria-Coated Filaments.—H. Nelson. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 353.) Summary of American Physical Society 1950 Annual Meeting paper EP5. Factors studied were: adhesion of thoria to the base metals W, Mo, Ta and Pt, ease of activation, and final level of thermionic emission. Pt was best for adhesion but least satisfactory for activation. The final emission level, reached at 1 900 °K, was about 5 A/cm² for W, Mo and Ta.

621.385.032.216 : 621.3.011.2 2078

Electrical Conductivity of Oxide-Cathode Coatings.—D. A. Wright. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 355.) Summary of American Physical Society 1950 Annual Meeting paper EP16. Conductivity measurements and Hall-effect measurements on activated coatings give results of which the former are and the latter may be in agreement with the Vink-Loosjes theory. P-type conductivity is not found in well activated coatings, but develops when emission is drawn under non-activating conditions; it is due to oxidizable impurities. The importance of surface phenomena is emphasized; these are associated with electron or hole movement rather than ion movement.

621.385.032.216 : 621.385.2 2079

Diode Studies of Oxide-Coated Cathodes.—H. E. Kern & R. T. Lynch. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 355.) Summary of American Physical Society 1950 Annual Meeting paper EP19. A description of the Bell Laboratories planar test diode, with a summary of standard procedures for applying and testing cathode coatings.

621.385.032.216 : 621.385.2 : 537.583 2080

The Decay and Recovery of the Pulsed Emission of Oxide-Coated Cathodes.—R. M. Matheson & L. S. Nergaard. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, pp. 355–356.) Summary of American Physical Society 1950 Annual Meeting paper EP22. The cathodes were investigated in cylindrical diodes with anode/cathode spacing 0.019 in. Observations of decays are noted. I/V characteristics obtained by use of short sampling pulses are compared with computed ideal characteristics; it is not possible to distinguish definitely between the effects of variation of emission and of internal cathode impedance; further studies on this aspect are in progress.

621.385.032.216 : 621.385.2 : 537.583 2081

A 'Figure of Merit' and a 'Quality Ratio' for D.C. Emission from Oxide-Coated Cathodes.—C. D. Richard, Jr. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 356.) Summary of American Physical Society 1950 Annual Meeting paper EP25. Tests with oxide-coated cathodes in diodes are considered, where E_g/I_k curves serve as criteria. The 'figure of merit' is the slope of a tangent to the 'knee' of the curve, and the 'quality ratio' is the ratio of figure of merit for the test specimen to that for a control specimen. Correlation with visual comparison of curves and with actual performance is good.

621.385.032.216 : 621.385.2 : 537.583 2082

Determination of Oxide-Cathode Performance in Diode Tubes through Figures of Merit.—T. H. Briggs. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 356.) Summary of American Physical Society 1950 Annual Meeting paper EP26. The criteria 'figure of merit' and 'quality ratio' proposed by Richard (2081 above) are useful for assessing variation of cathode activity with time and with chemical composition. A relation which may be significant for thermionic-emission theory has been found between the figure of merit and ratings proposed by Cardell and others for low-field and pulsed emission.

621.385.032.216.001.4 2083

Life Tests of Oxide-Coated Cathodes — an Engineering Report.—J. O. McNally. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 356.) Summary of American Physical Society 1950 Annual Meeting paper EP23. The development over a period of years of long-life cathodes is described, and the influence of operating temperature and current density is discussed.

621.385.1 : 621.396.822 2084

Noise Spectra from Vacuum Tubes at Ultra Low Frequencies.—R. W. Bogle. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 354.) Summary of American Physical Society 1950 Annual Meeting paper EP12. Noise measurements were made on a variety of valves, including both commercial and specially constructed types, and using all the common emitting materials, over the range 0.01–10 000 c/s. Observed results were in disagreement with the requirements of Johnson's flicker-effect theory in that there was no simple inverse proportionality of noise voltage to frequency and no sure evidence of flattening of the curve below a certain frequency point.

621.385.15 2085

New Multiplier Phototubes of High Sensitivity.—A. Sommer & W. E. Turk. (*J. sci. Instrum.*, May 1950, Vol. 27, No. 5, pp. 113–117.) High cathode-sensitivity and high multiplication factor are combined with high signal/noise ratio. In one type the photocathode consists of a circular semitransparent deposit about 1 cm diameter in the centre of a flat window. This type of tube is particularly suitable for scintillation counting.

621.385.2 2086

Measurements on Total-Emission Conductance at 35-cm and 15-cm Wavelength.—G. Diemer & K. S. Knol. (*Philips Res. Rep.*, Oct. 1949, Vol. 4, No. 5, pp. 321–333.) Results of measurements for a wide range of anode voltages and saturation currents are given. The valve used was an experimental disk-seal diode with a cathode/anode distance of about 15 μ. Values of the electronic capacitance are also given. The experimental results do not at all agree with the linear-field theory proposed by Thomson (1554 of 1948). For the space-charge-limited region the total-emission conductance did not play an important part relative to the conductance due to the transconductance; this may probably be explained by the screening effect of the space charge.

621.385.2 2087

Note on Total-Emission Damping and Total-Emission Noise.—A. van der Ziel. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, p. 562.) Expressions are derived for a diode at u.h.f. The result for the damping is the same as that given by Begovich (2959 of 1949) but in a slightly different notation. See also 2098 of 1949 (Freeman).

621.385.2[.3] : 621.315.59 : 546.815.221 2088

Crystal Diode and Triode Action in Lead Sulphide.—H. A. Gebbie, P. C. Banbury & C. A. Hogarth. (*Proc. phys. Soc.*, 1st May 1950, Vol. 63, No. 365B, p. 371.) With diode connection, rectification ratios of 2000 : 1 at 1.5 V have been observed, and with triode connection voltage amplification factors up to 25 and power gains of about 4. Other resemblances between the properties of PbS and Ge are mentioned. A full report of the investigations will be published later.

621.385.2 : 621.315.59 2089

Magnetically Biased Transistors.—C. B. Brown. (*Phys. Rev.*, 1st Dec. 1949, Vol. 76, No. 11, pp. 1736–1737.) A transverse magnetic field concentrates the hole current near the surface, reducing the average path length and resulting in less phase dispersion. Graphs indicate the improvement of characteristics and show that the upper frequency limit for $\alpha > 1.5$ (α = slope of collector-current/emitter-current curve) increased from 2 Mc/s to 10 Mc/s for a typical unit when a field of 6900 gauss was applied.

621.385.2 : 621.315.59 : 621.314.632 2090

D.C. Characteristics of Silicon and Germanium Point-Contact Crystal Rectifiers: Part 1 — Experimental.—H. J. Yearian. (*J. appl. Phys.*, March 1950, Vol. 21, No. 3, pp. 214–221.) Typical d.c. current/voltage characteristics obtained for Si and Ge crystal rectifiers are described. A survey of published theories shows that none of them will account for the principal features of the observed characteristics. An obvious discrepancy occurs in the case of the forward characteristic, where the current rise with increasing voltage is much less than indicated by theory. Conditions which a satisfactory theory must meet are outlined.

621.385.2 : 621.315.59 : 621.314.632 : 537.311.33 2091

D.C. Characteristics of Silicon and Germanium Point Contact Crystal Rectifiers: Part 2 — The Multicontact Theory.—Johnson, Smith & Yearian. (*See* 1941.)

621.385.2 : 621.306.822 2092

On the Retarding-Field Current in Diodes.—R. Fürth & D. K. C. MacDonald. (*Proc. phys. Soc.*, 1st April 1950, Vol. 63, No. 364B, pp. 300–302.) A development of an earlier theoretical treatment (4088 of 1947) of the space-charge distribution in a cylindrical diode under retarding-field conditions. The views expressed by Bell (2960 of 1949) on the effective cathode temperature in cylindrical diodes are shown to be theoretically unsound and to have been based on operation at a current above the limiting value.

621.385.3 2093

New Super-Power Beam Triode provides Output of 500 000 Watts.—(*Broadcast News*, March/April 1950, No. 58, pp. 8–9.) Illustrations and a few details of the R.C.A. Type 5831 transmitting valve. 48 independent triodes are arranged symmetrically within a cylindrical housing, the individual filament and grid rods being tungsten rods 8 in. long supported at both ends in V notches. The construction enables a simple water-cooling system to be used.

621.385.3 2094

Microphonism in the Dynamically Operated Planar Triode.—J. A. Wenzel & A. H. Waynick. (*Proc. Inst. Radio Engrs*, May 1950, Vol. 38, No. 5, pp. 524–532.) The effect of sinusoidal transverse oscillation of each electrode on the anode current of a planar triode is discussed theoretically. The case of simultaneous variation of the grid voltage is considered and it is shown that microphonic anode currents result at the sum and difference frequencies of the electrical and mechanical excitations. Experimental verification of the theory and a method of reducing microphony in audio amplifiers are described.

621.385.4.01 2095

The Computation of Electrode Systems in which the Grids are Lined Up.—J. L. H. Jonker. (*Philips Res. Rep.*, Oct. 1949, Vol. 4, No. 5, pp. 357–365.) Formulae are developed for the paths of the electrons and the position of the focus in a system of electrodes in which the grids are aligned. These formulae are applied to the calculation of a planar arrangement with prescribed characteristics and with zero screen-grid current when the control grid is at zero potential.

621.396.615.14 2096

Technology of Electronic Valves used for U.H.F.—R. Suart. (*Radio franç.*, April 1950, No. 4, pp. 1–9.) Illustrated description of the principles and construction details of the klystron, magnetron and disk-seal triode.

621.396.615.141.2 2097

A Toroidal Magnetron.—O. Buneman. (*Proc. phys. Soc.*, 1st April 1950, Vol. 63, No. 364B, pp. 278–288.) The design described, for which the name 'torotron' is proposed, has a ring cathode lying within a concentric toroidal anode having radial resonator slots. The electric field is radial and the magnetic field, which may be produced by a heavy current in the cathode, circles around the cathode. The electrons travel at right angles to these crossed fields, i.e. along the cathode. Theoretical calculations for the static and operating conditions are given and compared with those for a conventional magnetron. It seems likely that the proposed form would operate satisfactorily at high powers with good efficiency and mode stability.

621.396.615.141.2.032.21 : [537.533.8 + 537.581 2098

Thermionic and Secondary Emission Properties of Magnetron Cathodes and their Influence on Magnetron Operation.—R. L. Jepsen. (*Phys. Rev.*, 1st May 1950, Vol. 78, No. 3, p. 354.) Summary of American Physical Society 1950 Annual Meeting paper EP11. Magnetrons with secondary-emission cathodes exhibit on the V/I performance chart a 'maximum-current boundary' which can be understood by considering only stable thermionic and secondary-emission properties of the pure

metals of which the cathodes are composed. When the current is low, back bombarding power increases rapidly as anode current decreases; the electron interaction causing this is not yet understood.

621.385 + 621.396.6 **2099**

Fundamentals of Vacuum Tubes. [Book Review]—A. V. Eastman. Publishers: McGraw-Hill Book Co., New York, 3rd edn. 1949, 600 pp., $5.50. (*Proc. Inst. Radio Engrs*, April 1950, Vol. 38, No. 4, p. 450.) "Intended primarily for the use of senior electrical students. . . The main emphasis appears . . . to be directed more particularly to the uses of vacuum tubes than to the physical properties of the tubes themselves . . . The subject of special tubes and circuits for ultra-high-frequency uses has been omitted as demanding either a seriously curtailed treatment or an undesirably long book."

MISCELLANEOUS

519.283 : 658.562 : 621.397.62 **2100**

Quality Control in TV Receiver Production.—L. Lutzker. (*TV Engng, N.Y.*, Feb. 1950, Vol. 1, No. 2, pp. 6–9, 37.) Description of the introduction of a statistical technique and sampling inspection into a particular production line, with a consequent reduction in production costs.

538.56.029.6 **2101**

Technique and Applications of Ultra-Short Waves.—J. Franeau. (*HF, Brussels*, 1949, Nos. 4 & 5, pp. 91–102 & 143–148. In French.)

539 **2102**

Rutherford Memorial Lecture (1948).—E. Marsden. (*Proc. phys. Soc.*, 1st April 1950, Vol. 63, No. 364A, pp. 305–322.) Rutherford's early background and fundamental work on radioactivity and the atom, described by one who studied under him.

621.317.2 **2103**

The 'Laboratoire Central d'Électricité', 1882–1949. The New Laboratory at Fontenay-aux-Roses.—L. Sartre. (*Rev. gén. Élect.*, Jan. 1950, Vol. 59, No. 1, pp. 5–22.) A review of the development of the L.C.E., which in 1942 became the 'Laboratoire central des Industries électriques' and subsequently occupied vast new buildings near Paris. The work undertaken in this new laboratory includes the maintenance of national electrical standards and the calibration and testing of electrical instruments and materials. The installations and test equipment in the different sections are described, with numerous photographs.

621.385.001.4 : 519.283 **2104**

Statistical Evaluation of Life Expectancy of Vacuum Tubes Designed for Long-Life Operation.—E. M. McElwee. (*Sylvania Technologist*, April 1950, Vol. 3, No. 2, pp. 16–20.) Full text of paper noted in 1559 of June (No. 20).

621.392 (Cauer) **2105**

In Memoriam, Wilhelm Cauer.—Nai-Ta Ming. (*Elektrotechnik, Berlin*, May 1948, Vol. 2, No. 5, pp. 158–159.) Short account of Cauer's life and work, with lists of published and unpublished papers.

621.396 **2106**

Radio Progress during 1949.—(*Proc. Inst. Radio Engrs*, April 1950, Vol. 38, No. 4, pp. 358–390.) A comprehensive report, including over 800 references, based on material compiled by the 1949 Annual Review Committee of the Institute of Radio Engineers. The various sections deal with aerials and waveguides, audio techniques, network and circuit theory, electroacoustics, valves and solid-state devices, electronic computers, facsimile, industrial electronics, modulation systems, navigation aids, nuclear science, piezoelectric crystals, radio transmitters, railroad and vehicular communications, receivers, research, sound recording and reproducing, symbols, television systems, video techniques and television, wave propagation.

621.396 **2107**

The Tron Family.—W. C. White. (*Electronics*, May 1950, Vol. 23, No. 5, pp. 112, 114.) An explanatory list of over 200 words ending with 'tron'. For an earlier list see 2302 of 1947.

621.396 : 061.3 **2108**

1950 [Australian] I.R.E. Radio Engineering Convention, Melbourne, May 3rd–6th.—(*Proc. Instn Radio Engrs, Aust.*, May 1950, Vol. 11, No. 5, pp. 124..140.) Summaries are given of 29 technical papers presented at the convention.

621.396.6 **2109**

I.R.E. Convention Exhibits herald New Equipment.—(*Tele-Tech*, March 1950, Vol. 9, No. 3, pp. 32–34.) Illustrated descriptions of new electrical and radio products.

621.3 **2110**

Elektrotechnik des Rundfunktechnikers. Teil 1: Gleichstrom. (Electrotechnics for the Radio Technician. Vol. 1: Direct Current) [Book Review]—J. Kammerloher. Publishers: Deutscher Funk-Verlag. (*Elektrotechnik, Berlin*, Feb. 1950, Vol. 4, No. 2, p. 63.) A recommended book written by a professional teacher, with the minimum amount of higher mathematics. The contents include: fundamental laws of the d.c. circuit in free space; the electric field; the magnetic field; phenomena of extended circuits; recurrent networks.

621.3 **2111**

Lehrbuch der Elektrotechnik. Vol. 1. [Book Review]—G. Oberdorfer. Publishers: Leibnizverlag, Munich, 5th edn. 502 pp. (*Elektrotechnik, Berlin*, Feb. 1950, Vol. 4, No. 2, p. 63.) "Can be well recommended to all earnest students."

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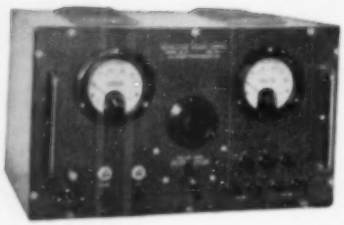

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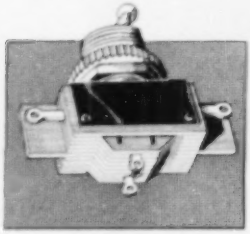

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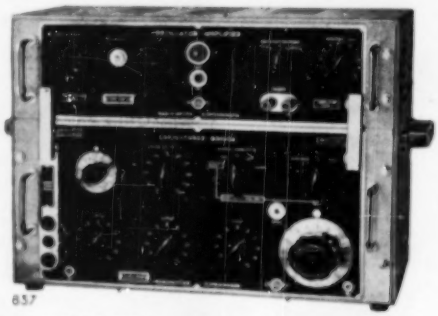

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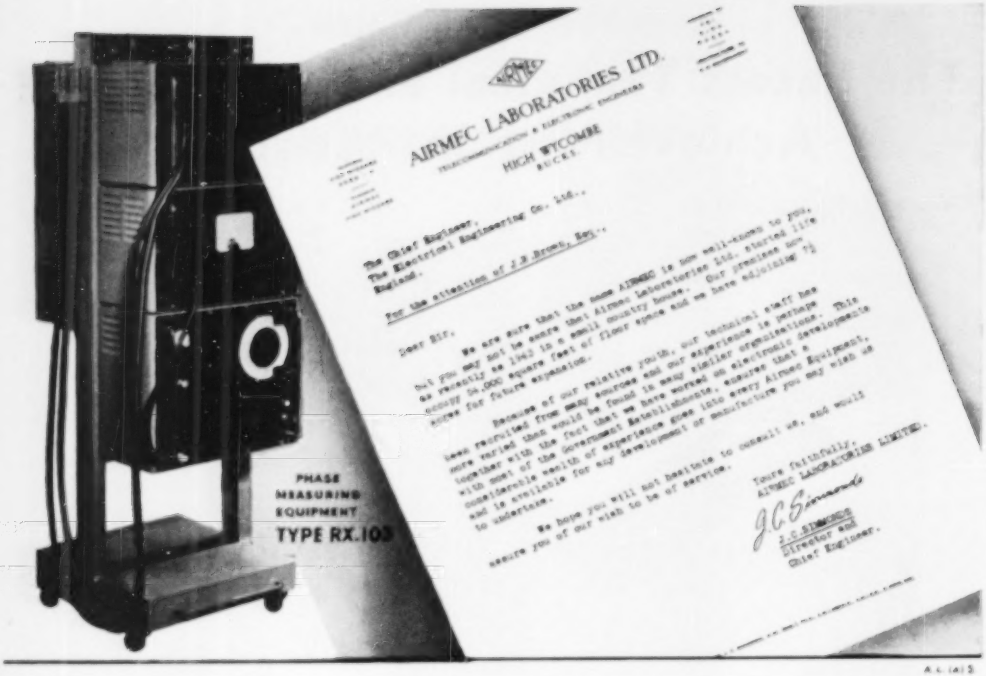

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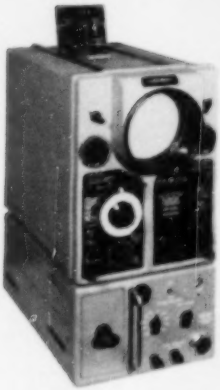

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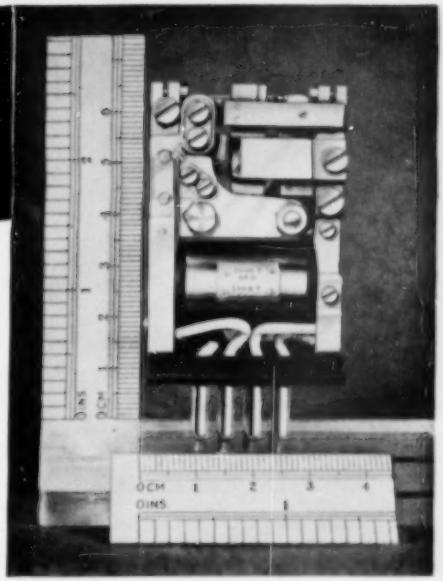

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Contact Pressure at 4 ampere turns R.M.S. 12 grammes. Maximum speed without bias disturbance on contact chatter, 60 c/s. At about 65 c/s. there is some bias, of the order of 5% but above this the Relay works faultlessly up to about 120c/s.

TYPE 5C. As Type 5A but with soldering tags instead of plug-in base.

TYPE 5B. Centre stable model, plug-in base 12 pins. With total contact gap of .002 ins. (i.e. .001 in. on either side) this model has the following characteristics :—

Centre stability 3 grammes.

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Minimum excitation 3.0 ampere turns R.M.S at 50 c/s.

Working excitation for robust operation 4 ampere turns* R.M.S. at 50 c/s.

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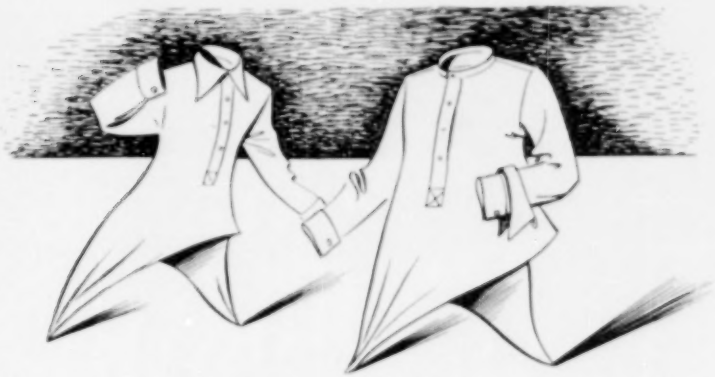

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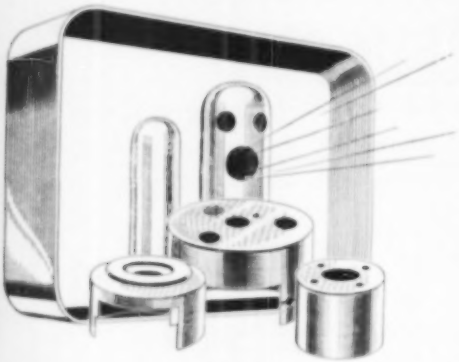

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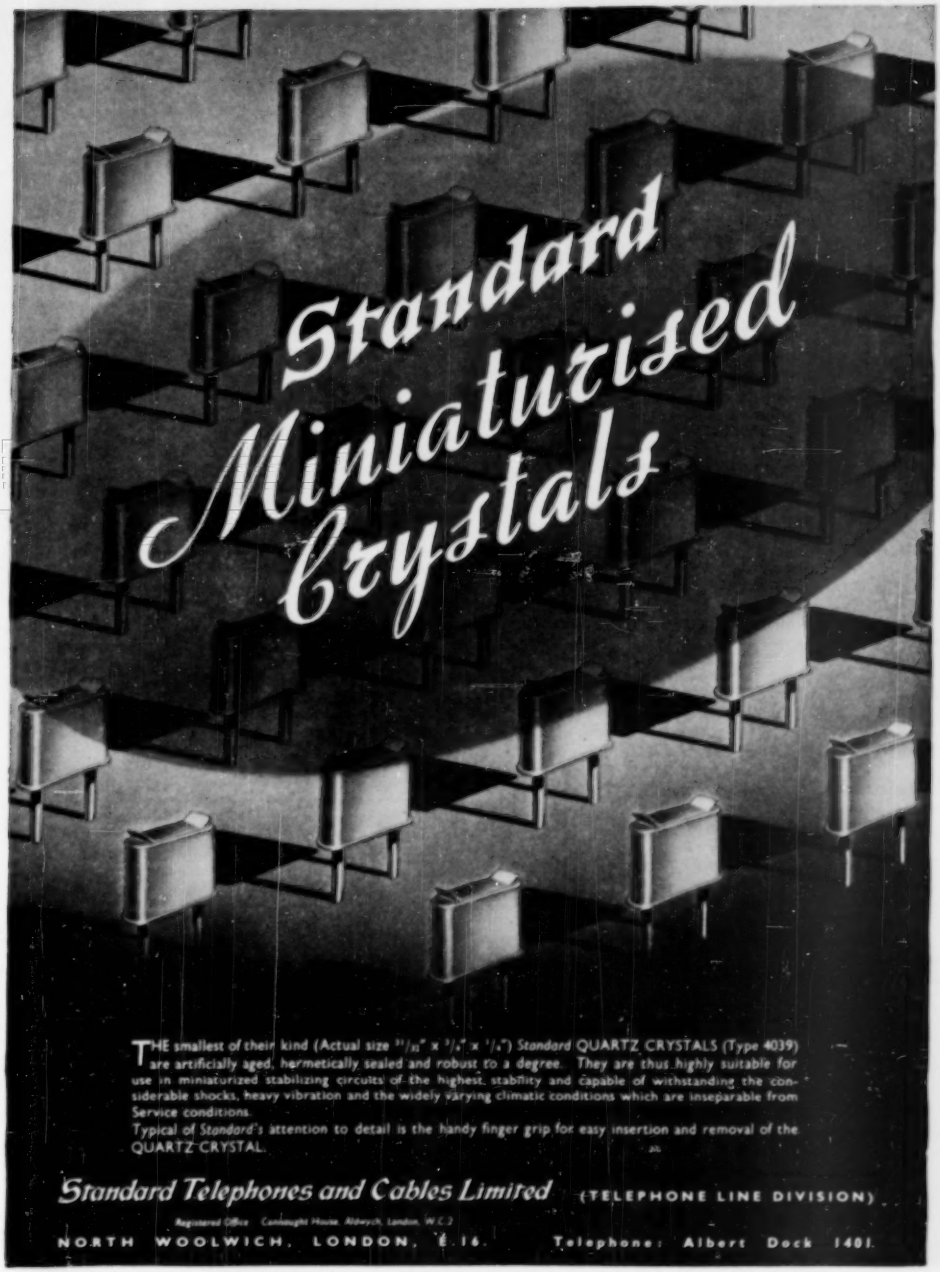

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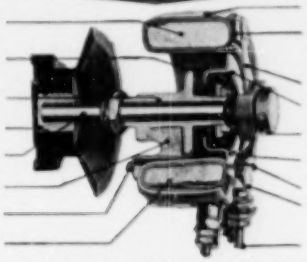

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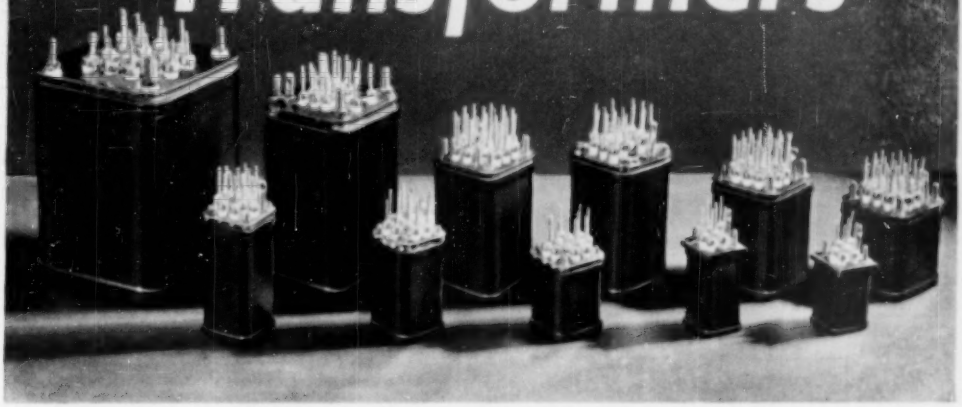

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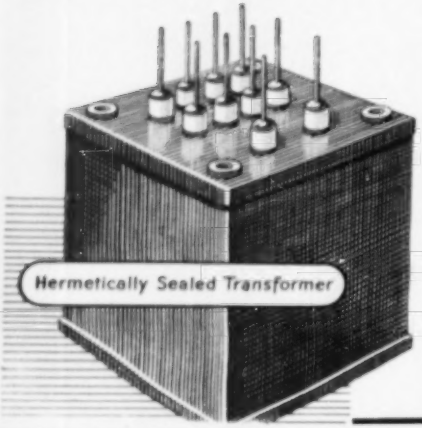

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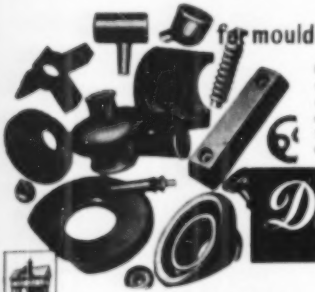

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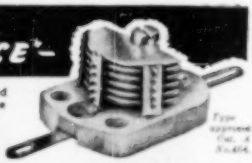

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